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Department of
Agriculture

Animal and
Plant Health
Inspection
Service

Plant Protection
and Quarantine

Rangeland Grasshopper Cooperative Management Program

Final Environmental Impact Statement — 1987

MENT

RANGELA MENT PROGRAM

APHIS FEIS 87-1

Responsible Official and Agency: Bert Hawkins, Administrator
USDA Animal and Plant Health Inspection Service
Washington, D.C. 20250

Cooperating Agencies: USDA Forest Service; U.S. Department of the Interior, Bureau of Land Management and Fish and Wildlife Service

Preferred Alternative: Integrated pest management, including chemical and biological controls, research on cultural/mechanical methods, data base development based on surveys to enhance outbreak prediction capabilities, and environmental monitoring

States Involved: Washington, Oregon, California, Nevada, Idaho, Utah, Arizona, New Mexico, Colorado, Wyoming, Montana, North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, Texas, and Alaska

Abstract: This EIS describes alternative methods of grasshopper control to be used in APHIS' cooperative programs beginning in 1987. APHIS' preferred alternative, integrated pest management (IPM), has been developed to incorporate elements of an interagency IPM pilot project, begun in 1986, for long-range programmatic consideration. Under the preferred alternative, malathion, carbaryl, acephate sprays, carbaryl bait, and Nosema locustae bait would be currently available; research would continue on other chemical and biological methods and on cultural/mechanical methods. Data base development based on survey results would also be used to enhance APHIS' outbreak prediction capabilities, and environmental monitoring results would be used to refine operational procedures. As methods become operational, APHIS would conduct environmental analyses to supplement this EIS for consideration in its program.

This EIS examines potential impacts on soils, vegetation, wildlife, water quality and aquatic systems, human health and worker safety, air quality, socioeconomics, historic and cultural resources, visual resources, and noise levels. Any potential adverse impacts would be avoided through adherence to the operational procedures and mitigation measures provided.

Requests for additional information should be addressed to Charles H. Bare, Staff Officer, PPQ-APHIS-USDA, Federal Building, Room 663, Hyattsville, MD 20782.

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March 1987

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OVERVIEW

This final programmatic environmental impact statement (EIS) describes alternative methods of grasshopper control to be used in the USDA Animal and Plant Health Inspection Service's (APHIS') cooperative program beginning in 1987. APHIS' preferred alternative, integrated pest management (IPM), has been developed to incorporate elements of an interagency IPM pilot project, begun in 1986, for long-range programmatic consideration. Under the preferred alternative, malathion, carbaryl, and acephate sprays, carbaryl bait, and Nosema locustae bait would be currently available; testing would continue on other chemical and biological methods and on cultural/mechanical methods. Data base development based on survey results would be used to enhance APHIS' outbreak prediction capabilities, and environmental monitoring results would be used to refine operational procedures.

This EIS also describes the environment that might be affected and discloses the potential environmental consequences of implementing any of the alternatives. It is prepared pursuant to the requirements of the National Environmental Policy Act (NEPA), the Council on Environmental Quality (CEQ) regulations for implementing NEPA, the Department of Agriculture's procedures for implementing NEPA (7 CFR 1(b)), and the APHIS guidelines for implementing NEPA (44 FR 50381-50384 and 44 FR 51272-51274).

In April 1986, APHIS made available the Supplement to the July 1980 Final Environmental Impact Statement (FEIS) for the Rangeland Grasshopper Cooperative Management Program. That FEIS, as supplemented, was intended for the 1986 treatment program only. Based on EPA and other agency comments on the 1980 FEIS and the 1986 supplement, APHIS committed to prepare this new EIS to cover the program beginning in 1987.

This final EIS also provides the basic background information needed for the "tiering" of future project-specific analyses on rangelands in accordance with the CEQ regulations for implementing NEPA (40 CFR 1502.20 and 40 CFR 1508.28). That is, should any future cooperative agreements or treatments funded in whole or in part by APHIS require an environmental assessment, that assessment will incorporate, by reference, the findings of this EIS and then concentrate only on the relevant issues of that specific project. Site-specific assessments of operations proposed for Forest Service lands or lands administered by the Department of the Interior are prepared by the land management agency on whose lands the treatment might occur in accordance with memoranda of

understanding with those agencies. In the case of private or State lands, APHIS is responsible for the preparation of site-specific assessments. However, cooperative agreements are negotiated with each State, and the State may assume the responsibility for site-specific EA's as part of its agreement. APHIS has final responsibility for all site-specific environmental assessments.

In addition, as grasshopper control methods that are currently undergoing testing become available for implementation into APHIS' program, this programmatic final EIS will be supplemented as necessary.

In accordance with 40 CFR 1501.6, the lead agency responsible for an EIS (in this case, APHIS) may request the cooperation of agencies that have legal jurisdiction or that have special expertise with respect to any environmental issue. The Bureau of Land Management and the Fish and Wildlife Service in the U.S. Department of the Interior and the Forest Service in the U.S. Department of Agriculture are cooperating in the preparation of this EIS. These cooperating agencies have participated in the scoping process and have offered special expertise in developing information and reviewing analyses used in this EIS.

Public participation has been an integral part of the preparation of the draft and final EIS. In accordance with 40 CFR 1501.7 and 1506.6, scoping comments were solicited both by mail and at two public scoping meetings held in Denver, Colorado, and Boise, Idaho. During the comment period on the draft EIS, comments were solicited by mail. Commenters included representatives of Federal, State, and local governmental agencies; public interest groups; environmental groups; universities; and concerned individuals. In addition, APHIS has considered comments on the 1986 EIS, as supplemented, in preparing this EIS.

APHIS' COOPERATIVE PROGRAM

Grasshopper and Mormon cricket infestations are often so extensive that individual land managers alone cannot control them. In addition, the migratory and widespread nature of grasshoppers and Mormon crickets makes coordination of cooperative management efforts across State boundaries essential. Therefore, APHIS provides direct supervision and leadership for grasshopper and Mormon cricket management programs in cooperation with other Federal agencies, State Departments of Agriculture, and private individuals.

APHIS' cooperative management programs are authorized by the Incipient and Emergency Control of Pests [Act] (1937), the Organic Act of the Department of Agriculture (1944), the Cooperation With State Agencies in the Administration and Enforcement of Certain Federal Laws Act (1962), and the Food Security Act of 1985. In addition, each State has basic pest

control authority, which allows it to participate in cooperative pest management programs.

APHIS' grasshopper program consists of four basic functions: surveying, establishing control procedures, monitoring, and methods development. The degree of APHIS participation in cooperative grasshopper management activities depends on landownership. APHIS generally pays the full cost of treating Federal lands, one-half the cost of treating State land, and one-third the cost of treating private land. Cost-sharing depends on funds available to APHIS for conducting grasshopper management programs. Public involvement is an important part of the process of planning control operations.

The potential control methods that could be used to treat grasshoppers include chemical sprays, chemicals or biological agents used in bait formulation, and cultural/mechanical methods involving range management practices. The choice of control method depends on the type of habitat, the time of application, grasshopper species composition, other environmental considerations, and cost. In planning a cooperative treatment, APHIS meets with the requesting agency or landowner to discuss the control options available, given these considerations. The actual method chosen must be one agreed upon by both APHIS and the cooperator, and it must be evaluated in this EIS in order for APHIS to participate.

Traditionally, APHIS has responded to economically critical levels of infestation in implementing chemical control treatments. The figure of eight adult grasshoppers per square yard has been used as the minimum population at which a program will be considered. This figure was derived by Parker (1939) as the level of infestation at which grasshoppers generally begin to compete with livestock for available forage. APHIS recognizes that other site-specific factors, such as grasshopper and plant species composition, life-cycle stage of the grasshoppers present, and condition of the range, also affect the degree to which an infestation is economic. Normally, programs are not conducted unless the populations are two to three times greater than eight per square yard. However, APHIS is authorized by Congress to take preventive measures at lower levels of infestation to avoid such critical outbreaks (37 FR 6327). Although funding for preventive treatments is currently limited, APHIS is considering a preventive approach to grasshopper control in its long-range integrated pest management alternative. In addition to funding constraints, such a preventive or anticipatory approach to prevent grasshopper outbreaks requires a willingness on the part of private, State, and Federal cooperators to participate and invest in long-range surveying and control strategies where appropriate, rather than relying solely on the traditional reactive or crisis-oriented approach.

ALTERNATIVES CONSIDERED

In general, alternatives recommended by commenters during the scoping process fell into the following categories:

(1) Cultural/mechanical methods
(2) Biological methods
(3) Chemical methods
 (a) Sprays
 (b) Baits
(4) Integrated pest management (combinations of cultural, biological, and chemical methods)

Several alternatives were considered by APHIS but eliminated as not practical for grasshopper control at the programmatic level. These included the use of cultural/mechanical methods alone, the use of biological methods alone, harvesting grasshoppers, or the use of the insecticide dimethoate. The reasons for eliminating these alternatives from detailed study are described in chapter 2.

Alternatives Selected for Detailed Analysis

The grasshopper control methods available to APHIS have been grouped into three broad alternatives for detailed analysis: no action (that is, no control by APHIS), the use of chemical controls only, and integrated pest management. This section describes each of these alternatives and the methods that are components of each.

Alternative 1--No Action

Under the "no action" alternative, APHIS would not fund or participate in any program to control grasshoppers or Mormon crickets. Some States, and perhaps some Federal land management agencies, would be able to fund and conduct survey or control programs. Individual landowners also could conduct programs on their properties. APHIS would neither provide funding for nor participate in any such programs under this alternative.

Implementation of the no action alternative for APHIS' long-range program is unlikely because APHIS is authorized to control grasshoppers under several Federal acts. However, NEPA implementing regulations require an agency to consider the no action alternative, even if an agency is under a court order or legislative command to act (40 FR 18026). The analysis of the no action alternative provides a benchmark or baseline against which the impacts of the other alternatives can be measured. Thus, for the purpose of establishing a baseline for the analysis, it is assumed that no grasshopper treatment occurs under the no action alternative, when in fact individual landowners or other agencies may continue to use chemicals without APHIS participation. These groups may use chemicals that are more toxic than those proposed for use by APHIS, and they may not be subject to environmental analysis

requirements or adhere to operational procedures designed to minimize adverse effects.

Alternative 2--Chemical Controls

Under the chemical control alternative, chemical insecticides would be used in APHIS' long-range cooperative program. The insecticides that would be used--carbaryl, acephate, and malathion--were selected both because they have been proven to be effective in grasshopper control programs and because their toxicity to mammals is relatively low. All three have been extensively tested in the field, and the effects of each have been well documented in the scientific literature. In addition, each of the three chemicals has been approved by EPA for use on rangelands. Two primary methods of application would be used in grasshopper control: ultra-low-volume (ULV) aerial spraying of all three chemicals and aerial application of carbaryl bait. In addition, carbaryl baits could occasionally be applied by ground equipment.

Alternative 3 (Preferred Alternative)--Integrated Pest Management

Integrated pest management is the selection, integration, and implementation of pest control tactics in a systems approach on the basis of anticipated economic, ecological, and sociological consequences. As implemented by APHIS, the selection of the IPM alternative would allow biological or chemical methods to be selected singly or in combination for grasshopper control and would involve ongoing research and testing to identify other feasible control methods (including cultural/mechanical methods) that could be phased into future IPM programs. As the definition of IPM implies, the selection of a particular control method or combination of methods on an individual site would take into consideration several factors, including economic (the cost and the cost-effectiveness of various methods in both the short and long term), ecological (the impact on nontarget organisms and the environment), and sociological (the acceptability of various IPM methods to cooperators, or the potential effects on land use) factors.

As noted by several commenters during scoping, grasshopper control programs traditionally have relied heavily on suppressing grasshopper outbreaks after they occur. The primary means used for suppression has been insecticides. The primary aim of the IPM alternative would be to develop means by which outbreaks could be predicted and prevented and to develop alternative methods of grasshopper control (for both prevention and suppression) that minimize the use of chemicals.

Under the preferred alternative, APHIS has identified components of an IPM strategy that are currently available as well

as those considered appropriate for further testing. As methods currently in research and development become operational, APHIS will conduct environmental analyses and supplement this EIS for their consideration.

Currently Available Methods Under IPM. Under the IPM alternative, APHIS would choose among various methods, depending on site-specific factors. The methods currently available include the use of carbaryl, acephate, or malathion sprays; carbaryl bait; and a biological control agent, *Nosema locustae*.

Nosema is a naturally occurring protozoan parasite of many species of grasshoppers, including Mormon crickets. It appears not to affect other species of insects or any other plant or animal species. In samples taken in natural conditions where Nosema occurred, Henry (1972) found that it was present in about 5 percent of grasshoppers and that species varied in susceptibility. Nosema is transmitted within existing populations by cannibalism brought on by overcrowding, and laboratory studies have shown that approximately 5 percent of the offspring of infected females are themselves infected.

Available data indicate that approximately 50 percent of infected individuals survive for 4 to 6 weeks (Henry et al., 1973). Because it is slower acting, Nosema is most effective if introduced in the early stages of an infestation or when an infestation is predicted to occur. The bran bait used with Nosema appears to be most accepted by grasshoppers at the third or fourth instar. Infected grasshoppers do not consume as much as uninfected individuals, and they are more vulnerable to predation and cannibalism, particularly during moulting. Cannibalism further spreads the infection. Onsager (1986a) described two field experiments in which infestations treated with Nosema were abated over 1 or more years while untreated infestations remained high. Thus, Nosema shows promise as being effective in suppressing population levels in years following its introduction.

Henry and Onsager (1982) concluded that Nosema could be "potentially useful" in an integrated control program. Wright (1985) stated that because of its relatively high cost per acre, Nosema would have high utility where environmental considerations were of primary importance. Nosema has only recently been marketed for grasshopper control on rangelands. It was first used as part of APHIS' grasshopper control program in 1986 after undergoing extensive research over the past decade or more. Limited production capacity constrained the amount available for use in 1986; in that year, APHIS treated approximately 25,000 acres with Nosema. The remainder (majority) of Nosema produced that year was used in programs conducted by private groups. It is currently anticipated that production capacity in 1987 will be sufficient to allow Nosema

to be used on a total of 1-1/2 million to 2 million acres. Within 3 years, production capacity should be adequate for treating 5 million to 6 million acres annually (Evans, personal communication, 1986).

Potential Future Components of the IPM Alternative. APHIS' grasshopper control program is supported by research (conducted by the Agricultural Research Service) and methods development components. Control methods under research and testing that could ultimately be transferred into field use through the IPM pilot project include the following: inflight encapsulation of insecticide spray; varying rates and application times for Nosema; other formulations of carbaryl bait; carbaryl/Nosema bait mixtures; *Entomophaga grylli*, a fungal pathogen of grasshoppers; entomopox viruses; and cultural/mechanical methods. Cultural/mechanical methods include various techniques of range management as well as the physical destruction of grasshopper eggs. Testing of the potential usefulness of range management techniques as a method of grasshopper control would involve examining the effects of livestock grazing practices and prescribed burning on grasshopper infected areas.

Sentinel site surveys are conducted by APHIS to provide information on grasshopper population trends. The development of a data base from these surveys would assist APHIS in mapping grasshopper species composition and in identifying relationships between outbreaks, the conditions or practices that trigger or accompany outbreaks, and the long-and short-term efficacy of various control methods. This, in turn, could prove extremely valuable in developing future control programs.

The IPM Pilot Project

In the early summer of 1986, an interagency technical work group was formed to initiate a long-term integrated pest management pilot project for grasshopper control. The interagency group included representatives of the Bureau of Land Management (BLM), National Park Service (NPS), and Fish and Wildlife Service (FWS) from the Department of the Interior; the Forest Service, Agricultural Research Service, Economic Research Service, Extension Service, and APHIS from the Department of Agriculture; and the Environmental Protection Agency (EPA).

The objectives and tentative plans for the first year of the IPM pilot project are described below. A budget of $3 million has been approved for the first year of the IPM pilot project. Staffing, equipment, and services will be supplied by each of the nine Federal agencies involved and through cooperative agreements with State universities.

The IPM pilot project will be headquartered in the BLM State Office in Boise, Idaho. It has been conceived as a 5-year demonstration project, although funding must be approved from year to year.

The objectives of the IPM pilot project are as follows:

(1) Refine an existing phenology model to maximize efficiency of management activities.

(2) Demonstrate that early sampling can detect and classify incipient infestations that are amenable to management with alternative registered tactics.

(3) Develop economic thresholds and prescribe selective or nonselective treatments to reduce infestations to noneconomic levels with minimum effects on nontarget species.

(4) Quantify current-season and long-term responses of infestations following each available control tactic in order to support a model of population dynamics in response to treatments.

(5) Develop new selective methods for management of grasshoppers, including grasshopper virus and fungal pathogens.

(6) Provide for coordinated research on economics, range management, and ecology of nontarget species as components of a systems approach to grasshopper management.

(7) Integrate all pertinent data into one expert system that can be turned over to APHIS and private enterprise upon completion of the project.

Major aspects of the project will be accomplished at two demonstration sites in McKenzie County, North Dakota, and the Boise BLM District in Idaho. Alternative work sites will include Johnson County, Wyoming, and the Vale BLM District in Oregon. These demonstration sites represent the major ecosystems within which grasshopper outbreaks usually occur in the West.

Each demonstration site will include roughly 1 million acres. Testing of various management strategies and no treatment sites (checks) will be conducted on infested acres. A maximum of 100,000 acres per year may be treated in each demonstration site on as many as 10 different blocks. Treatment will be dictated by the phenological factors and will be in accord with the grazing use pattern for the particular area. One of the primary aims of this effort will be to test methods at their optimum period of effectiveness, rather than to be required to wait for a cooperator request before initiating

treatment. Thus, the extent to which planned tests are actually implemented will depend on the occurrence of optimum infestation and climatological conditions.

For a method that is tested in the IPM pilot project to be considered for incorporation into APHIS' cooperative program, it would have to have been adequately tested, registered by EPA (if applicable), commercially available, and approved by the IPM Work Group as ready for transfer from research and testing into field use. Those that are actually tested and accepted will depend upon funding available to the project, and they will be incorporated on a priority basis. Priorities will be assigned based on stage of development of the method and on those options that show the most promise (in terms of long- and short-term efficacy, environmental soundness, and the like) in initial testing.

In addition to testing of control methods, other IPM pilot project components include environmental effects monitoring, posttreatment efficacy evaluations, range management, economic data collection, and data base development/predictive modeling. As the project progresses, the various components will be adjusted to fit particular needs. Data collection will be an ongoing function for the duration of the project.

The tentative first-year work plans for each of the components of the IPM pilot project are summarized in chapter 2. Work plans for future years will depend upon the direction taken and results of the first year.

Operational Procedures and Mitigation Measures

A number of measures to increase the safety and reduce the impacts of APHIS' control program have been incorporated as operational procedures and mitigation measures for the alternatives being considered. The operational procedures would be a required part of programs funded by APHIS, while the mitigation measures are recommended for consideration at the site-specific level. The operational procedures are presented in table 2-1 in chapter 2 and recommended mitigation measures are presented in table 2-2.

THE AFFECTED ENVIRONMENT

The rangelands of the 17 western States and parts of Alaska are the environment potentially affected by the APHIS grasshopper and Mormon cricket cooperative management program. These vast rangeland areas are a valuable natural resource providing grazing for domestic livestock, food and cover for a variety of wildlife species, and recreational resources for the public.

Rangeland environments are areas that are generally too dry for intensive agriculture or forestry. The potential natural vegetation is predominantly grasses, grass-like plants, forbs, or shrubs. Rangeland includes natural grasslands, savannahs,

shrublands, most deserts, tundra, and alpine communities. These lands produce a significant portion of livestock for the country, and they support grazing and browsing big-game animals.

Most of the grazed range in the contiguous United States is located in the 17 States west of the Mississippi River (see figure 3-2 in chapter 3). The most extensive and economically important rangeland areas are the grasslands and savannas of the Great Plains and Texas, the mountains and deserts of the West, and the annual grasslands of California. In Alaska, grazing lands are located primarily in the lowlands of the Yukon-Kuskokwim Basins and the Tanana Valley. In 1976, almost two-thirds of the 820 million acres of rangelands in the contiguous United States and Alaska were grazed. Of that acreage, two-thirds consisted of non-Federal range and the remaining third was federally owned. Most non-Federal grazed lands are in the prairie States. For example, 98 percent of the range grazed in the six Great Plains States is privately owned. Further west, Federal ownership is greater; and in the Pacific Northwest, Federal lands constitute more than one-half of the grazed range (USDA SCS, 1981).

The impacts of the APHIS management program may differ from one rangeland area to another in the western States and Alaska because of differences in physical characteristics, such as climate or ground-water supplies, or because certain biological elements, such as plant productivity or endangered species, differ. To address these potential differences, Alaska and the western States were partitioned into eight rangeland regions. The eight regions are the tall-grass prairie, short-grass prairie, plateau, desert, Great Basin, California grassland, mountain, and Alaska Delta Junction. Chapter 3 provides descriptions of the eight analysis regions. Where the effects of the APHIS grasshopper control program would differ among regions, those differences are addressed in chapter 4. Resources that are unique to specific proposed treatment areas will be addressed in site-specific environmental assessments.

There are a number of grasshopper species that are considered economically important because of their damage potential. Some of those frequently found in the western United States are Ageneotettix deorum, Aulocara elliotti, Phlibostroma quadrimaculatum, Melanoplus bivittatus, Melanoplus differentialis, Melanoplus femurrubrum, Melanoplus sanguinipes, and Camnula pellucida. Figure 3-7 in chapter 3 shows the economically important grasshopper species by State.

ENVIRONMENTAL AND SOCIOECONOMIC EFFECTS

This EIS examines the range of impacts that could result from carbaryl, acephate, or malathion sprays, carbaryl bait, or Nosema. Because carbaryl is commercially formulated with

petroleum oils and is mixed with diesel oil as a carrier for application, impacts of diesel and petroleum oils also are addressed. (EPA has listed petroleum oil and diesel oil as inerts of toxicological concern.) Although it is not currently used in APHIS control programs, the carbaryl formulation Sevin XLR Plus may be considered for future use, depending on results of efficacy tests. EPA has classified the aqueous formaldehyde used as a preservative in Sevin XLR Plus as an inert of toxicological concern. This EIS addresses the risks associated with this formaldehyde constituent.

Risks to aquatic species and humans are analyzed under routine operational conditions and under accidental scenarios, such as the jettisoning of a 200-gallon load of insecticide into a reservoir and, in the case of humans, a spill of insecticide onto a worker's clothing or a direct spraying of a child at the full application rate. Conservative assumptions are used throughout the risk analysis in estimating the effects of the alternative control methods on humans, wildlife, and aquatic organisms so that no potential impacts that might occur will be overlooked.

Readers are cautioned that the following text is a summary of impacts. The bases for the conclusions summarized here are presented in detail in chapter 4 and in the hazard and exposure analyses in appendixes A and B.

Summary of Impacts on Soil and Vegetation by Alternative

No Action

During heavy infestations, virtually all vegetation in the area would be threatened, and plant growth could be retarded for several years. Plant removal by grasshoppers would leave the ground surface vulnerable to increased sunlight and rainfall. This could lead to serious erosion problems and disturbance of soil organisms.

Chemical Control Alternative

All three chemicals proposed for use in grasshopper control are rapidly degraded and would not have significant impacts on soils or soil organisms. Densities of soil microorganisms could be temporarily affected but should return to pretreatment levels within a short period. The three insecticides are generally nonphytotoxic; that is, they are generally not poisonous to plants, and direct spraying is not expected to have any adverse impacts on vegetation. A 500-foot buffer zone will be maintained around all crops for which a ULV insecticide being applied is not registered. Thus, no adverse effects to nonregistered crops should occur. Chemicals act quickly to reduce grasshopper infestations; thus damage to vegetation from grasshopper foraging would be minimized.

IPM Alternative

Under the IPM alternative, the total amount of chemicals used in a given year would be less than that used under the chemical control alternative. No adverse impacts to vegetation are expected from the use of any of the chemicals under this alternative. Nosema would not cause adverse effects to vegetation. Although it persists in soil, it has no effect on the soil or soil organisms. However, because it is slower acting, some damage to rangeland and nearby crops may occur before grasshopper populations are significantly reduced.

As improvements in predictive modeling and the early introduction of Nosema help prevent grasshopper outbreaks, adverse impacts on vegetation from grasshopper outbreaks would be greatly reduced.

Summary of Impacts on Wildlife by Alternative

No Action

If grasshopper infestations are not controlled, virtually all grasses and forbs could be destroyed in an affected area and plant growth could be retarded for several years. This would result in a localized disruption of habitat providing food and cover for wildlife species. The overall number of animals and the diversity of species could be reduced by direct mortality, reduced reproductive success, and emigration from the area.

Chemical Control Alternative

The chemicals are slightly to moderately toxic to birds and mammals, and highly toxic to honey bees. Operational procedures (table 2-1) would mitigate adverse impacts to honey bees, alkali bees, or leafcutter bees. However, there could be adverse impacts to wild pollinators.

Field studies indicate that there have been no significant direct toxic impacts on wildlife in areas treated with chemicals at application rates similar to those proposed for the current program. Studies with higher application rates than those of the grasshopper program reported movement and displacement of avian species as a result of reduced insect populations needed for food.

Based on the results of the risk assessment, the chemicals ranked in order of increasing risk to wildlife are acephate, carbaryl bait, carbaryl spray, and malathion. Depression of cholinesterase (ChE) levels may occur in small mammals and birds. Effects of ChE inhibition are not fully understood, but they could cause inability to gather food, escape predation, or care for young. Individual granivorous mammals or birds that ingest carbaryl bait flakes could experience toxic effects or fatality.

Petroleum oils in Sevin 4-Oil and the diesel oil carrier used with Sevin 4-Oil may reduce egg production and hatchability in birds. Some direct toxicity of the insecticides to eggs via absorption through the shells may occur.

Thus, grasshopper control activities may have local indirect impacts on wildlife, such as ChE depression and resulting behavioral changes, fatalities, egg contamination, and loss of food supply leading to reduced survival and/or reproductive success. However, because less than 1 percent of the total western rangeland acreage is likely to be sprayed in any one season, only a fraction of the total range of most wildlife species would be affected. Local reductions in food supply and other effects causing lowered survival and reproductive success therefore should not constitute a significant threat to the species throughout its overall range.

Site-specific environmental assessments will be prepared in cooperation with the Fish and Wildlife Service and State wildlife agencies and will address potential impacts on federally listed endangered and threatened species, candidate species, State-listed species, and limited range or unstable populations. Site-specific protection measures will be developed as needed.

APHIS is committed to ensuring that any alternative chosen under the grasshopper management program complies with the Endangered Species Act. The process of formal and informal consultation with the Fish and Wildlife Service is described in chapter 5 of this EIS. APHIS has prepared a Biological Assessment for the 17 western States and Alaska that analyzes the effects of the three proposed chemical insecticides on endangered and threatened wildlife. Protection measures for endangered and threatened species are proposed in the Biological Assessment and are subject to further modification in the Biological Opinion prepared by the Fish and Wildlife Service.

IPM Alternative

Under this alternative, the impacts of chemicals on wildlife, as described above, would be proportionally lower. Nosema is highly specific to grasshoppers, and no adverse impacts to wildlife or honey bees would be expected from its use.

Summary of Impacts on Water and Aquatic Species

No Action

Grasshopper consumption of vegetative ground cover could cause increased sedimentation and turbidity because of increased soil erosion. This would decrease photosynthesis of aquatic plants and reduce the productivity of the aquatic ecosystem.

Chemical Control Alternative

Operational procedures call for a 500-foot buffer between areas treated with ULV insecticides and a 200-foot buffer between areas treated with carbaryl bait and bodies of water supporting higher aquatic life. Thus, under normal operating conditions, there should be no long-term effects to any species of aquatic organism from using carbaryl, acephate, or malathion in grasshopper control operations. No fish or crayfish should be killed. Populations of aquatic insects could be reduced, particularly in streams, by malathion or carbaryl, but any effects should be temporary.

If carbaryl were directly sprayed onto a reservoir, or if severe storm runoff into a stream occurs after spraying carbaryl or malathion, some aquatic insects and invertebrates would be severely affected. In an accident where reservoirs are directly sprayed with malathion or where 200 gallons of carbaryl or malathion spray mixtures are jettisoned into a reservoir, fish and other aquatic species would be severely affected. However, these situations are unlikely and are not expected to occur. No adverse effects should result from diesel or petroleum oils under routine conditions, although fish kills and reductions in aquatic invertebrates would result if a load is jettisoned into a reservoir.

IPM Alternative

Impacts of chemicals on aquatic environments would be proportionately less under this alternative. Nosema would have no impacts on water quality or aquatic species.

Summary of Impacts on Human Health by Alternative

No Action

Because chemicals would not be used under this alternative, no impacts to human health from chemical use in APHIS programs would occur. However, severe infestations could cause regional declines in rangeland productivity and livestock production, which would adversely affect human communities that depend on them.

Chemical Control Alternative

Under routine circumstances and given compliance with the operational procedures, no significant health impacts to workers or the general public are expected from the use of any of the three chemicals in grasshopper control activities. Malathion or acephate exposures to sensitive individuals may cause some symptoms of cholinesterase inhibition even under routine circumstances. These symptoms could include dizziness, headache, or nausea. Similar effects could occur to sensitive members of the public in the case of accidental direct spraying

or spraying of a leafy crop. Smaller accidental exposures, for example, direct spraying of a reservoir, are unlikely to cause significant adverse effects. An accidental spill of any of the three chemicals on a worker could result in moderate to severe symptoms of cholinesterase inhibition, such as vomiting, abdominal cramps, blurred vision, and loss of muscle control.

Because the findings regarding the carcinogenicity of the pesticides considered for use are inconclusive, APHIS conducted a theoretical cancer risk analysis for carbaryl, acephate, and malathion. Maximum cancer risk to the public from exposure to acephate is 3.8 in 10 million; to workers, 4.5 chances in 1 million. Maximum cancer risk to the public from exposure to malathion is less than 5 chances in 1 million; to workers, 1.6 chances in 10,000. Maximum cancer risk to the public from exposure to diesel oil is 1 chance in 800 million; to workers, 1 chance in 10 million. The small formaldehyde component of Sevin XLR Plus would not add significantly to the cancer risk to the public exposed to carbaryl; the risk to workers would be less than 1 chance in 1 million. Carbaryl is not a carcinogen, but it could theoretically be converted to the known carcinogen N-nitrosocarbaryl under certain conditions in the stomach. Thus, cancer risk for carbaryl has been calculated for dietary exposures to the public only. Maximum cancer risk to the public through dietary exposure to carbaryl is 1.6 chances in 100,000.

IPM Alternative

This alternative combines the benefits of control methods with lower risk to human health, such as the use of Nosema and carbaryl bait where it is feasible, with the advantages to the livestock industry of quick response to heavy infestation when that response is necessary. Overall impacts on human health should be somewhat lower than those under the chemical control alternative.

Other Environmental Effects

In accordance with the CEQ regulations for implementing NEPA, other environmental effects are addressed in this EIS. These include cumulative environmental effects; adverse environmental effects that cannot be avoided; the relationship between short-term uses of man's environment and the maintenance and enhancement of long-term productivity; irreversible and irretrievable commitments of resources; possible conflicts between the proposed action and the objectives of Federal, State, and local agencies; and energy requirements.

Chapter 1
Purpose and Need

OVERVIEW

Grasshoppers have been recognized as a problem on rangeland in the western United States since the first settlers planted crops and grazed domestic livestock. Significant forage and crop losses still occur despite control measures by government agencies and individual ranchers. In 1985, for example, grasshoppers were the most widespread and caused the most damage since the major outbreaks in the late 1930's. An estimated 55 million acres were infested. Rangeland grasshoppers are common and cause forage losses in the 17 western States and parts of Alaska. This problem is of great concern both to ranchers whose livestock must compete with grasshoppers for forage and to government personnel who are responsible for decisions regarding grazing management and insect control (Hewitt and Onsager, 1983).

Mormon "crickets" are included in this environmental impact statement (EIS) because they are actually wingless longhorned grasshoppers that have periodically caused extensive damage to lands in the western United States, especially in Utah, Colorado, Nevada, Oregon, and Washington. They typically inhabit sagebrush-dominated semiarid intermontane rangelands and adjacent lowlands. In this EIS, the term "grasshopper" and analyses concerning grasshoppers are intended to include Mormon crickets unless otherwise specified.

Grasshopper and Mormon cricket infestations are often so extensive that individual land managers alone cannot control them. In addition, the migratory and widespread nature of grasshoppers and Mormon crickets makes coordination of cooperative management efforts across State boundaries essential. Therefore, the Animal and Plant Health Inspection Service (APHIS) of the U.S. Department of Agriculture (USDA) provides direct supervision and leadership for grasshopper and Mormon cricket management programs in cooperation with other Federal agencies, State departments of agriculture, and private individuals.

APHIS' cooperative management programs are authorized by the Incipient and Emergency Control of Pests [Act] (1937), the Organic Act of the Department of Agriculture (1944), the Cooperation With State Agencies in the Administration and Enforcement of Certain Federal Laws Act (1962), and the Food Security Act of 1985. In addition, each State has basic pest control authority, which allows it to participate in cooperative pest management programs.

TARGET ORGANISMS

Although there are several hundred species of grasshoppers in the United States, entomologists generally agree that only about 35 grasshopper species are perennial pests. These historically destructive species are generally grouped into two categories: rangeland grasshoppers and cropland grasshoppers. The most common grasshopper species causing economic damage and their distribution are described in chapter 3. APHIS' funding is limited to treatments on rangeland only; therefore, this EIS examines APHIS' control program for grasshoppers and Mormon crickets on rangeland.

Grasshopper species of economic importance prefer green vegetation to dry material. Most rangeland grasshoppers prefer native forbs and grasses, whereas cropland grasshoppers tend to be more general feeders, devouring both cultivated and native plants. Grasshoppers can occur in numbers so large that they can consume virtually all vegetation in an outbreak area. When relatively few grasshoppers are present, feeding is more selective; the grasshoppers eat only parts of the preferred host plants, such as corn silks, wheat heads, and the most tender part of grasses and forbs (Mulkern et al., 1969; Parker, 1954; Pfadt, 1977).

Grasshoppers have a biotic potential for sudden and explosive population increases. Outbreaks ordinarily are preceded by several years of gradual increases in grasshopper numbers, followed by a year in which conditions particularly favor grasshopper development. This results in a pyramidal increase and an extremely high number of grasshoppers during the first year of the outbreak. Without control, an outbreak may last 3 or more years (Parker, 1954).

Outbreaks are difficult to predict because they depend largely on climatic variables that cannot be predicted. The intensity of a grasshopper outbreak depends largely on the rate of population increase the preceding year and temperature and moisture conditions at the time of hatching. Population increases of considerably more than four times the previous year are common; during severe outbreaks, increases greater than 10 times the previous year often occur, producing 100 or more grasshoppers per square yard (Pfadt, 1977). Such populations can devour crops and native vegetation if control methods are not implemented.

Warm, dry weather is generally the most favorable for grasshoppers, and severe outbreaks are most often associated with drought. Natural factors that help keep grasshopper outbreaks from increasing at an enormous rate include unfavorable weather, such as extended cold, extended wet conditions, or both; natural enemies, including mammals, birds, insects, spiders, and disease; and lack of food.

Life History and Ecology of Grasshoppers and Mormon Crickets

Most grasshopper species deposit their egg pods about 1 inch below the soil surface in late summer or early fall. The number of eggs in a pod and the number of egg pods laid depend upon the species, food availability, and the length of the laying season (Parker, 1954). In nature, the average female probably lays approximately 20 eggs (Scharff, 1960), although laboratory studies have reported average egg production of 200 to 300 (Pfadt et al., 1979). The eggs lie dormant in the winter and hatch the following spring or early summer.

Young grasshoppers, called nymphs, emerge as miniature versions of the adult. The nymphs moult five or six times and are incapable of flight until after their final moult into the adult stage (Parker, 1954). In a few species, adults have only wing pads and cannot fly. Grasshoppers on rangeland are capable of banding together into large swarms. Swarms numbering more than 300,000 individuals in a 1 to 2 acre area are common during outbreaks (Parker, 1952).

Mormon cricket eggs are deposited singly about 1 inch deep in the soil throughout the summer and early fall. Eggs remain in the soil during the winter and hatch during the first warm days of spring, usually a full month earlier than other grasshopper species. They pass through seven nymphal stages during approximately 75 to 100 days and are fully developed adults by early June to mid-July. However, while eggs laid in the soil will usually hatch the next year, many remain dormant until the second year. This creates problems in trying to predict the size of a population and may account for unexpected increases in populations from one year to the next. Although the Mormon cricket is wingless, this characteristic does not prevent migrations. From the time the cricket is half grown, it is capable of "migrating" more than a mile a day in no predictable direction. Although Metcalf and Flint (1939) reported migration bands sometimes covering a square mile in area and often consisting of 100 to 500 individuals per square foot, a recent National Park Service study seldom observed average band densities over 30 individuals per square yard (U.S. DOI, 1987). Migration occurs all summer with intermittent feeding and periods of egg laying.

Grasshoppers and Mormon crickets have evolved with present-day native grasses, forbs, and sagebrush. These plants and many animal species are intimately associated and interdependent. Dyer and Bokhari (1976) showed that range grasses were stimulated by some grasshopper feeding and that these grasses produced more growth and biomass than plants that were totally protected. For example, the saliva and droppings from grasshoppers stimulate plant growth. In addition, the uneaten cuttings of leaves and other plant parts constitute litter, which helps retain soil moisture and provides nutrients for plant growth. Furthermore, grasshoppers are an important animal

food source for many omnivorous as well as insectivorous mammals, birds, and fish. They are widely distributed, readily available, and contain a high percentage of crude protein (Ueckert et al., 1972).

NEED FOR CONTROL ACTIVITIES

It is apparent that grasshoppers are a significant part of healthy range ecosystems and are important for food chains, energy flow, and forage production. However, these benefits are negated when grasshoppers reach high densities. Forage destruction by infestations of grasshoppers is a complex function of grasshopper density, species composition, feeding rates, and average longevity. Overgrazing by grasshoppers is at least as detrimental as overgrazing by vertebrate herbivores (such as cattle). Typically, rangelands under grasshopper pressure are also stressed for moisture, intensifying a condition of marginal forage productivity. Significant loss of wildlife habitat may occur during outbreaks. Many grasshoppers are strong fliers and often move from dry rangelands to croplands and other vegetation, causing severe damage (Pfadt, 1977). As previously stated, Mormon crickets also migrate over large areas even though they are wingless.

To provide a basis for more accurate assessments of economic damage by grasshoppers, a 3-year study was conducted through a cooperative agreement between the USDA's Economic Research Service and the University of Wyoming. Biological and economic models were developed to estimate grasshopper population dynamics, forage losses, and impacts on cattle weight gains. Study results indicated that grasshoppers cause damage that reduces the weight gain of animals, and, because of the reduced overall health of the herd, production, including calving rates, is adversely affected. Grasshopper damage also may change management practices, forcing producers to feed hay, sell early, reduce stocking rates, or relocate their herds (Mann et al., 1983).

Damage caused by grasshoppers goes beyond actual consumption of forage. Grasshoppers cut grass stems and blades, eating only a part. They eat closer to the ground than livestock and feed primarily on the growing part of grasses. They cut off seed stalks, thus reducing seed production and making soil erosion more likely in denuded areas (Parker, 1954; Parker and Connin, 1964).

It is known that grasshoppers waste approximately six times as much foliage as they consume. The consensus of a number of researchers places the quantity of forage destroyed on 1 acre by a population level of 1 grasshopper per square yard, from newly hatched ones to ones with 30 days of adult life, to be in the range of 12 to 15 pounds of forage (Hewitt, 1977; Hewitt, 1978; Humphrey, 1962; Isely, 1946; Nerney, 1958; Mulkern et al., 1969; Putnam, 1962).

Finally, the need for grasshopper control is evident in Hewitt and Onsager's (1983) estimate that the average dollar value of the annual forage lost to grasshoppers on the 262 million hectares (about 647 million acres) of western rangeland in 1977 (a typical treatment year) was about $393 million. This means that at least 23 percent of the total forage value in 1977 was lost to grasshoppers.

APHIS' COOPERATIVE GRASSHOPPER MANAGEMENT PROGRAM

Congress has authorized APHIS to undertake a program for the prevention, suppression, control, or eradication of grasshopper and Mormon cricket outbreaks on Federal, intermingled, and private lands.

It should be noted that a goal of APHIS' grasshopper management program is to reduce outbreak populations to noneconomic levels at the request of land managers or owners, as opposed to eradicating grasshoppers entirely. As discussed in chapter 2, APHIS is considering the possibility of maintaining subeconomic population levels through the use of integrated pest management.

APHIS currently controls grasshoppers and Mormon crickets by determining where economically important infestations are likely to occur, advising landowners and land managers of the potential hazard, and providing treatment assistance upon request if funding is available. Table 1-1 shows the number of acres by landownership category treated under APHIS' grasshopper and Mormon cricket programs conducted from 1972 through 1986. APHIS' grasshopper program consists of four basic functions: surveying, establishing control procedures, monitoring, and methods development.

Surveying

An evaluation of the need to control grasshoppers and Mormon crickets considers several factors, including the condition of the range, the desire of the land manager to participate in a cooperative program, and the number of grasshoppers or Mormon crickets present.

Three different types of surveys are conducted that influence the decision to apply controls. First, the nymphal survey provides the basis for predicting the need for control. Second, the delimiting survey provides the information necessary for identifying the program boundaries where control is needed. Third, the adult survey is used to provide a basis for predicting the following year's potential for economically important population development.

Nymphal Survey

The nymphal survey is conducted in the spring and early summer of the treatment year. Program personnel conduct surveys of the grasshopper nymphal populations, counting the number of

Table 1-1--Acres treated by landownership (in thousands)

Year	Federal	State and Private	Total
1972	950	1,250	2,200
1973	1,179	1,421	2,600
1974	263	554	817
1975	262	388	650
1976	589	264	853
1977	603	789	1,392
1978	608	208	816
1979	1,100	6,100	7,200
1980	900	4,400	5,300
1981	206	1,067	1,273
1982	6	574	580
1983	0	0	0
1984	217	0	217
1985	9,083	4,013	13,096
1986	4,221	2,615	6,836
Average	1,346	1,576	2,049

Source: PPQ, APHIS administrative data

grasshopper nymphs present. At the same time, the surveyor makes an assessment of the relative roles of egg-hatching rate and nymphal mortality, pathogens, and other potential natural control agents that may be working to influence the grasshopper population. Grasshopper nymphal survey sampling stops are made in sufficient numbers to provide the surveyor with current information about numerous factors, such as the stage of biological development; location of the grasshoppers; sensitive areas such as streams, apiaries, and wetlands; the condition of the rangeland in relation to grasshopper numbers; and the extent of the infestation. These data are then considered with other information (for example, weather forecasts) to help the cooperating group to decide just before treatments should begin whether to initiate a control program.

An alternative survey method has been developed and involves the establishment of "sentinel" sites that are monitored at 2-week intervals to provide population information. The sentinel site survey does not provide the information necessary to plan for control activities, but it does provide information on species composition, age, and building or declining population trends.

Sentinel sites are established in representative rangeland areas within each county with a history of economically damaging grasshopper populations. These sites are visited three times during nymphal development. Counts are made and the population's species composition is determined. This information will provide a data base for future program activities.

Delimiting Survey

When the nymphal survey or reports from cooperators identify potential problem areas, a delimiting survey is instituted to establish infestation boundaries. Although the procedures for estimating populations are the same as in nymphal and adult surveys, sampling stops are limited to the area where potential control programs are indicated.

Adult Survey

Grasshopper adult surveys begin soon after grasshoppers have dispersed from nymphal concentrations and have reached the adult stage. All infested areas are surveyed. This survey, conducted in the fall, is timed to coincide with peak populations, enabling completion of the survey before the grasshopper populations decline appreciably. The optimum time for observing adult populations in some areas may occur before formal adult surveys start due to the presence of early-hatching species. If so, the surveyor will count, record, and map these occurrences and add them to information gathered during the formal adult survey. Information about these known infestations is combined with the infestation information collected later and is classified and mapped to produce a yearly national outlook map that is used to develop estimates of the next year's populations.

The sentinel site survey method is also used in the adult survey. The sentinel sites used for the nymphal survey are visited when the majority of the grasshoppers have reached adulthood. Counts are made, the species composition is determined, and the results mapped for use in producing the national outlook map. Figures 1-1 and 1-2 illustrate areas for which economically important infestations were predicted in 1981 and 1986 based on results of these surveys conducted by APHIS.

Infestations of over 8 grasshoppers per square yard predicted.

Source: Adapted from 1981 Grasshopper Outlook, USDA, APHIS, PPQ.

Figure 1-1--Economic infestations predicted for 1981

Infestations of over 8 grasshoppers per square yard predicted.

Source: Adapted from 1986 Grasshopper Outlook, USDA, APHIS, PPQ.

Figure 1-2--Economic infestations predicted for 1986

Control Treatments

Treatment Site Selection

Using the results of the fall survey, APHIS tries to predict where economically important levels of infestation may occur the following spring. Once these predictions are made, the Federal and State land managers and private rancher committees meet in the winter to plan their control strategy for the following spring. At the time of the spring nymphal survey, APHIS can then verify whether economically important populations are in fact occurring in the predicted areas, and land managers and ranchers are again informed of APHIS' survey findings. Next, the affected land managers or ranchers submit letters of request for APHIS assistance in control activities. APHIS responds to such requests by conducting a delimiting survey to verify if economically important populations actually exist and to establish specific and accurate treatment boundaries. If other areas of infestation are identified during delimiting surveys, APHIS will notify the affected land manager or owner to submit a letter of request if he or she wishes to be included in the cooperative management program.

Should a request originate within a generally infested area, the proposed control area should be sufficiently large (not less than 10,000 contiguous acres) and workable or flyable to make the effort biologically sound.

An exception to the 10,000-acre minimum block size requirement is allowed under conditions of "incipient infestation." An incipient infestation is an economically important outbreak of any size threatening surrounding areas. APHIS will respond to requests to treat these smaller infestations, or "hot spots," to avoid having to treat larger areas later.

Small amounts of infested croplands usually exist within a proposed rangeland control program. Any cropland that cannot effectively be omitted is included as range, and the owner pays the usual rangeland portion. However, cropland cannot cover more than 20 percent of the total block size.

The degree of APHIS participation in cooperative grasshopper management activities depends on landownership. Cost-sharing depends on funds available to APHIS for conducting grasshopper management programs. The following section describes APHIS' cooperative management activities by landownership category.

Cooperative Activities

Federal Lands. Memoranda of Understanding have been executed with the various Federal land managing agencies, including the Forest Service and the Department of the Interior. These memoranda state that grasshopper control on such lands shall be administered by APHIS. APHIS generally pays the full cost

of treating Federal land and land administered by the Bureau of Indian Affairs, depending on specific lease arrangements. APHIS also pays up to one-half of the cost of treating State land and one-third the cost of private land that is intermingled in a proposed cooperative control program. The requesting agency is usually expected to provide assistance in flagging, storage, and arranging for equipment and services in accordance with the existing agreement. Actual treatments are conducted by private contractors under supervision by APHIS or the State.

State-Owned Lands. Critically infested State-owned rangeland is eligible for grasshopper control under the same conditions as outlined below for privately owned rangeland. Federal participation is limited to no more than one-half of the total cost of rangeland grasshopper control on State lands. Treatments are conducted by private contractors under APHIS or State supervision.

Privately Owned Lands. Grasshopper control on privately owned range involves joint responsibility of the owner, the State, and the Federal Government. Sufficient interest in control should prompt a timely rancher committee request for assistance and reflect a willingness by the ranchers to take the lead in program organization.

APHIS pays up to one-third of the total cost for treatment on privately owned rangelands, provided the landowners have arranged in advance for payment of the remaining two-thirds. In many States, the State pays one-third of the program cost for the private landowner.

Cropland. The U.S. Congress has indicated through appropriation language that cooperative grasshopper control programs are to be limited to treatments on rangelands only. However, in areas that are predominantly cropland, APHIS will provide technical assistance subject to available resources. This will include information on timing of control, suggestions for planning and organizing local control programs, and information on new control methods specific to large-scale operations. And, as mentioned previously, APHIS will treat cropland that is intermingled in a rangeland treatment block, as long as the cropland covers no more than 20 percent of the treatment block.

In addition, APHIS conducts crop border treatments to protect croplands threatened by infestations involving adjacent Federal rangeland. The 10,000-acre minimum block size does not apply to crop border treatments.

Control Methods

The potential control methods that could be used to treat grasshoppers include chemical sprays, chemicals or biological

agents used in bait formulation, and cultural/mechanical methods involving range management practices. The choice of control method depends on the type of habitat, the time of application, grasshopper species composition, and other environmental considerations. In planning a cooperative treatment, APHIS meets with the requesting agency or landowner to discuss the control options available, given these considerations. The actual method chosen must be one agreed upon by both APHIS and the cooperator, and it must be evaluated in this EIS in order for APHIS to participate. Chapter 2 describes in detail the alternative control methods available to APHIS and the methods currently being researched.

Traditionally, APHIS has responded to economically critical levels of infestation in implementing chemical control treatments. The figure of eight adult grasshoppers per square yard has been used as the minimum population at which a program will be considered. This figure was derived by Parker (1939) as the level of infestation at which grasshoppers generally begin to compete with livestock for available forage. APHIS recognizes that other site-specific factors, such as grasshopper and plant species composition, life-cycle stage of the grasshoppers present, and condition of the range, also affect the degree to which an infestation is economic. Programs are not normally conducted unless the populations are two to three times greater than eight per square yard.

However, APHIS is authorized by Congress to take preventive measures at lower levels of infestation to avoid such critical outbreaks (37 FR 6327). Although funding for preventive treatments is currently limited, APHIS is considering a preventive approach to grasshopper surveying and control in its longrange integrated pest management alternative. (See chapter 2.) In addition to funding constraints, such a preventive or anticipatory approach to prevent grasshopper outbreaks requires a willingness by private, State, and Federal cooperators to participate and invest in long-range surveying and control strategies where appropriate, rather than relying solely on the traditional reactive or crisis-oriented approach.

Public Involvement in Control Treatments

Public involvement is an integral part of the process of planning control operations. Public meetings are scheduled and notices posted in advance of all treatments. These meetings are used as a forum to discuss the need for treatment, materials and methods available for treatment, when programs should be conducted, and the procedures used in requesting treatment.

Meetings are held with ranchers who request information or who are interested in organizing control programs. Meetings also

are held with county extension agents to provide them with information on grasshopper and Mormon cricket populations and to advise them of the procedures for organizing and scheduling public meetings with concerned ranchers.

The public is kept apprised of scheduled control programs through notices in local newspapers and on local television and radio stations. Registered beekeepers are notified by mail of the possibility of control programs.

In addition, public participation is an important part of APHIS' compliance with the National Environmental Policy Act (NEPA), as discussed later in this chapter.

Monitoring

In conformance with its continuing responsibilities under NEPA to assess the environmental impacts of its programs, APHIS conducts monitoring in treatment areas as part of its grasshopper control program. As of 1987, this monitoring program will consist of sampling for residues in flowing or impounded, natural or manmade bodies of water supporting higher aquatic life (excluding stock tanks or pits) that are accessible in or adjacent to the treatment area; sediments in these water bodies; naturally occurring vegetation; and target insects in the treatment area. Any moribund wildlife found within the treatment area following treatment will be collected for pesticide residue analysis. All necessary Federal and State permits for collecting wildlife will be obtained for any monitoring conducted by APHIS. Because the biological control agent available for use in APHIS' program is highly target-specific and produces no known offsite impacts, monitoring is not conducted in conjunction with biological treatments.

All rangeland control programs on 20,000 acres or more will be monitored. The number of monitoring sites within a given program will be determined by the size of the spray block. Pretreatment samples of water, sediment, and vegetation will be collected from 1 to 10 days prior to treatment to establish a baseline for measuring posttreatment residue levels. All posttreatment samples except water will be taken 24 hours after treatment in programs using malathion, carbaryl, carbaryl bait, and acephate. Posttreatment water samples will be collected 15 to 30 minutes after treatment.

All samples are forwarded to the National Monitoring and Residue Analysis Laboratory (NMRAL) in Gulfport, Mississippi. The results are then used by APHIS to address any potential impacts that may have occurred and are used in planning future control treatments. More details of the techniques and procedures used in collecting and forwarding the field samples for residue analysis are outlined in appendix C, Pesticide Monitoring and Sampling Procedures.

In addition, APHIS will conduct a special monitoring program for sensitive areas, which was initiated during the 1986 grasshopper program and has been revised for the 1987 season and subsequent years. The sensitive area monitoring plan is presented in detail in appendix C and in the 1987 Biological Assessment prepared by APHIS. Modifications may be made as a result of the Biological Opinion to be prepared by the Fish and Wildlife Service.

The objective of the sensitive area monitoring program is to ensure that the protective measures employed during grasshopper control programs to prevent adverse effects on threatened, endangered, and other species of concern are effective. The following criteria are used to determine whether an area is a sensitive area:

(1) The presence of peregrine falcon nesting or hack sites within or immediately adjacent to a spray block.

(2) The presence of endangered or threatened fish within or immediately adjacent to a spray block.

(3) Any other condition when special monitoring is advisable in the opinion of the APHIS office in charge in discussions with the Fish and Wildlife Service and others.

(4) The first instance of the use of Sevin 4-Oil, carbaryl bait, ULV malathion, or acephate in each State on programs of at least 20,000 acres of totally federally owned land.

The same items monitored for residues in standard control programs (described above) will be monitored in sensitive areas. In addition, sensitive area monitoring will include bird censusing, whole body residue analyses on representative birds, and counting for population trends in aquatic macroinvertebrates following treatment.

Pretreatment samples as described above for standard monitoring will be taken. In addition, pretreatment samples of aquatic macroinvertebrates and bird residue levels will be taken 1 to 10 days prior to treatment. Posttreatment samples will be taken at the times described for the standard monitoring program. Bird residue levels will be sampled 24 hours after treatment. Aquatic macroinvertebrates will be sampled 1, 5, and 10 days following treatment. NMRAL will analyze sensitive area samples. Bird censusing will be done using standardized procedures outlined in Burnham et al. (1981).

Under the Integrated Pest Management (IPM) pilot project (described in chapter 2), additional monitoring will occur in demonstration sites, and research will take place to determine

the effects of grasshopper treatments on migratory birds and other resources.

Methods Development and Research

APHIS' cooperative grasshopper management program also includes a methods development component. The functions of this component are to provide solutions to problems, such as crop protection, that require immediate response; to refine existing grasshopper control methods and technology; and to provide long-term management solutions, such as controlling grasshoppers at subeconomic populations. Although APHIS is not a research agency, methods under research by the Agricultural Research Service (ARS) can be incorporated into the methods development program for field testing. Many of the current activities in methods development and research are a component of the IPM pilot project, as discussed in chapter 2.

SCOPE OF THE ENVIRONMENTAL IMPACT STATEMENT

The APHIS grasshopper and Mormon cricket management program must comply with the procedural provisions of the National Environmental Policy Act, 42 U.S.C. 4321 et seq. In April 1986, APHIS made available the supplement to the July 1980 Final Environmental Impact Statement (FEIS) for the Rangeland Grasshopper Cooperative Management Program. That FEIS, as supplemented, was intended for the 1986 treatment program only. Based on EPA and other agency comments on the 1980 FEIS and the 1986 supplement, APHIS committed to prepare this new EIS to cover the program beginning in 1987.

This EIS addresses APHIS-funded treatments on Federal, State, and private rangelands. For the purpose of this EIS, rangeland is defined as any area on which the vegetation consists of native or introduced grasses, legumes, grass-like plants, forbs, or shrubs, and that is currently developed for range (grazing) use. Also counted as rangelands are native pastures or meadows that are occasionally cut or mechanically harvested and grazed by livestock.

This final EIS also provides the basic background information needed for the "tiering" of future project-specific analyses on rangelands in accordance with the CEQ regulations for implementing NEPA (40 CFR 1502.20 and 40 CFR 1508.28). That is, should any future cooperative agreements or treatments funded in whole or in part by APHIS require an environmental assessment, that assessment will incorporate, by reference, the findings of this final EIS and then concentrate only on the relevant issues of that specific project. Site-specific assessments of operations proposed for Forest Service lands or lands administered by the Department of the Interior are prepared by the land management agency on whose lands the treatment might occur in accordance with memoranda of understanding with those agencies. In the case of private or State lands, APHIS is responsible for the preparation of site-specific

assessments. However, cooperative agreements are negotiated with each State, and the State may assume the responsibility for site-specific EA's as part of its agreement. APHIS has final responsibility for all site-specific environmental assessments.

In addition, as grasshopper control methods that are currently undergoing testing become available for implementation into APHIS' program, this programmatic final EIS will be supplemented, as necessary.

In accordance with 40 CFR 1501.6, the lead agency responsible for an EIS (in this case, APHIS) may request the cooperation of agencies that have legal jurisdiction or that have special expertise with respect to any environmental issue. The Bureau of Land Management and the Fish and Wildlife Service in the U.S. Department of the Interior and the Forest Service in the U.S. Department of Agriculture are cooperating in the preparation of this EIS. These cooperating agencies have participated in the scoping process and have offered special expertise in developing information and preparing analyses used in this EIS. (Chapter 6 describes the interdisciplinary team that has prepared this EIS.)

Public participation has been an integral part of the preparation of this final EIS. In accordance with 40 CFR 1501.7 and 1506.6, scoping comments for the draft EIS were solicited both by mail and at two public scoping meetings held in Denver, Colorado, and Boise, Idaho. Commenters included representatives of Federal, State, and local governmental agencies; public interest groups; environmental groups; and concerned individuals. The issues and concerns of the public, along with the programmatic requirements of APHIS, were analyzed and used to develop a range of alternatives and to evaluate these alternatives. The issues and concerns of the public also were used in assessing the impacts of the various alternatives, in developing mitigation measures and operational procedures to be incorporated in the alternatives, and in selecting the preferred alternative. In addition, APHIS has considered comments on the 1986 EIS, as supplemented, in preparing this EIS.

During the public comment period on the draft EIS, comments were solicited by mail from the entire mailing list presented in chapter 7 (except for recent additions). All comments received from the public on the draft EIS were considered in preparing this final EIS. The major issues of concern to the public were those regarding the biological control agent Nosema; impacts of control treatments on wildlife; the level of detail used to describe the affected environment; and the operational procedures that would be used to conduct the treatment operations. Many were in favor of an integrated pest

management approach that emphasizes preventive measures and long-term control.

ORGANIZATION OF THIS EIS

This EIS is organized to comply with the format specified in the CEQ regulations (40 CFR 1502.10). This chapter has described the underlying need for and purpose of APHIS' grasshopper control program. Chapter 2 describes the range of alternatives that was developed in response to the scoping process and the process by which some of the alternatives were eliminated from detailed study. Chapter 2 also lists the alternative control strategies that were considered in detail and a summary of the impacts that are described more fully in chapter 4. Operational procedures and mitigation measures are included for all alternatives. Chapter 3 describes the environment that will be affected by implementation of any of the alternatives. Chapter 4 describes, evaluates, and compares the alternative control strategies in terms of their environmental, social, and economic effects and in terms of the public's concerns. Chapter 5 describes the Federal, State, and local environmental regulations and consultation requirements associated with the control activities and outlines the process for coordination with appropriate State and local agencies. Chapter 6 contains the list of preparers, and Chapter 7 contains the distribution list for the draft EIS. Following Chapter 7 are the references cited.

Appendix A contains the hazard analysis and Appendix B contains the exposure analysis. Appendix C provides APHIS' updated pesticide monitoring and sampling procedures and Appendix D contains reproductions of all public comments on the draft EIS and APHIS' responses. Appendix E contains the glossary.

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Chapter 2
Alternative Strategies for the Management of Grasshoppers on Rangelands

INTRODUCTION

This chapter describes how APHIS formulated alternat[illegible] strategies for the control of grasshoppers on rangelands in the western United States and Alaska in its long-range cooperative management program. It briefly describes alternatives that were considered but eliminated fr[illegible] study and describes more fully the alternatives that w[illegible] selected for detailed analysis. It also describes the process by which a decision would be made under each alternative as to which control method would be used in particular situations. It lists operational procedures that would be required under the various alternatives (table 2-1, located at the end of this chapter) and recommended measures that could be taken to further mitigate adverse impacts of the alternatives (table 2-2, also located at the end of this chapter). Finally, it presents a summary of the impacts on the human environment of each of the alternatives.

THE DEVELOPMENT OF ALTERNATIVES

During the scoping process for this Environmental Impact Statement (EIS), APHIS requested that comments be submitted in writing and at two public scoping meetings (51 FR 20950). Comments were requested from more than 350 individuals, organizations, and Government agencies. APHIS placed advertisements in newspapers serving areas near the scoping meetings and notified major media outlets in those areas where scoping meetings would be held. Oral and written comments were received from more than 48 individuals and organizations, and commenters represented the entire range of interests comprised by the mailing list. APHIS considered all these comments, as well as comments received from the public on [illegible] 1986 EIS, as supplemented, in determining the scope of the issues to be addressed in this EIS and in developing the alternatives.

Most commenters agreed that grasshopper control was necessary. However, many of these commenters had suggestions or recommendations regarding the methods to be used in any control program. In general, alternatives recommended by commenters fell into the following categories:

(1) Cultural/mechanical methods

(2) Biological methods

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(3) Chemical methods

(a) Sprays

(b) Baits

(4) Integrated pest management (combinations of cultural, biological, and chemical methods)

The considerable interest in an integrated pest management (IPM) approach to grasshopper control shown by EPA, the cooperating agencies, and the general public was a major force behind the preparation of this EIS. Concurrent with the scoping process for this EIS was the formation and development of an interagency group composed of representatives from nine involved Federal departments and agencies to consider an integrated pest management approach to manage grasshopper populations at and below economically important levels, using strategies that are cost-effective and environmentally acceptable. The IPM pilot project developed by this group was an important element used in developing the preferred alternative, as discussed in a later section.

ALTERNATIVES ELIMINATED FROM DETAILED STUDY

This section describes the alternatives considered by APHIS but eliminated as not practical for grasshopper control at the programmatic level.

Cultural/ Mechanical Control Methods Alone

Cultural/mechanical methods of grasshopper control include physically destroying grasshopper eggs, as well as using range management techniques such as grazing management, prescribed burning, scalping and furrowing, and seeding. While these methods may affect populations, their potential usefulness in controlling grasshoppers is largely untested. APHIS could not meet its current programmatic responsibilities in grasshopper control by relying solely on these methods. Therefore, the use of cultural/mechanical methods alone has been eliminated from detailed study.

The integrated pest management alternative, described later in this chapter, includes the option for research on several cultural/mechanical methods, including grazing management, prescribed burning, and egg destruction. Should the IPM alternative be adopted, these cultural/mechanical methods could be used in the future if research shows they are useful in grasshopper control.

Biological Control Methods Alone

The only biological control method currently available is Nosema locustae, a naturally occurring protozoan parasite of many species of grasshoppers, including Mormon crickets. As discussed in the description of the integrated pest management (IPM) alternative, Nosema is used most effectively in a preventive approach to outbreaks. It is less effective if

introduced after the majority of grasshoppers have reached the third nymphal instar. Nosema can effect up to a 50-percent reduction in grasshopper populations over several weeks and may provide some residual protection for one or more years following treatment (Henry et al., 1973). Methods for making consistently accurate predictions of grasshopper outbreaks are lacking. Thus, Nosema, which takes some time to effect population reductions, would not help meet the continuing need for immediate control of outbreaks. In addition, the commercial production of Nosema is not currently great enough for it to be used on all the acreage treated by APHIS in its cooperative program. Therefore, an alternative consisting of biological methods alone is eliminated from detailed consideration in this EIS. However, the use of Nosema is one of several operational methods included in the IPM alternative. In addition, other biological control methods, including a fungus (*Entomophaga grylli*) and a group of pathogenic viruses (entomopox viruses), are slated for testing and possible future implementation under the IPM alternative.

As in all methods, other naturally occurring parasites and predators such as large mammals, rodents, reptiles, amphibians, birds, spiders, mites, insects, and worms, as well as internal parasitoids, also would influence grasshopper populations. The incidence of parasites and predators increases with higher grasshopper densities, thus contributing to reduced longevity in the grasshoppers (Hewitt and Onsager, 1983). However, any effect would typically lag behind grasshopper population changes, so they have little influence once grasshopper or Mormon crickets reach outbreak levels. Thus, it is not practical to rely on parasites and predators for suppression of outbreaks.

Harvesting

A recommendation put forth during the scoping process was that APHIS consider allowing grasshoppers to be harvested. The suggestion was that the grasshoppers could be collected by hand or machine, ground into a paste, and the paste marketed as a protein supplement for livestock or humans. This suggestion is impractical as a method to be used in APHIS' program. Grasshopper outbreaks can occur on millions of acres, so collection by hand would be impossible. In addition, no machinery suitable for harvesting grasshoppers is known to exist. And, considering the relatively low cost of other livestock foods, developing a market for such a grasshopper paste seems unlikely. For these reasons, grasshopper harvesting was not considered in this EIS.

Cygon 400 Insecticide

One commenter suggested that APHIS use the Cygon 400 (a registered trademark of American Cyanamid Corporation) formulation of dimethoate in its grasshopper control program. This insecticide was eliminated from consideration in this EIS because it is not registered for use for grasshopper control

on rangeland in all of the States in which APHIS conducts control programs and because of its higher acute toxicity relative to the other pesticides being considered.

ALTERNATIVES SELECTED FOR DETAILED ANALYSIS

The grasshopper control methods available to APHIS have been grouped into three broad alternatives for detailed analysis: no action (that is, no control by APHIS), the use of chemical controls only, and integrated pest management. This section describes each of these alternatives and the methods that are components of each.

Alternative 1—No Action

Under the "no action" alternative, APHIS would not fund or participate in any program to control grasshoppers or Mormon crickets. Some States, and perhaps some Federal land management agencies, would be able to fund and conduct survey or control programs. Individual landowners also could conduct programs on their properties. APHIS would neither provide funding for nor participate in any such programs under this alternative.

Implementation of the no action alternative for APHIS' long-range program is unlikely because APHIS is authorized to control grasshoppers under the Incipient and Emergency Control of Pests [Act] (1937), the Organic Act of the Department of Agriculture (1944), the Cooperation With State Agencies in the Administration of Certain Federal Laws Act (1962), and the Food Security Act of 1985. However, NEPA implementing regulations require an agency to consider the no action alternative, even if an agency is under a court order or legislative command to act (40 FR 18026). The analysis of the no action alternative provides a benchmark or baseline against which the impacts of the other alternatives can be measured.

Alternative 2—Chemical Controls

Under the chemical controls alternative, insecticides would be used in APHIS' long-range cooperative program. The insecticides that would be used--carbaryl, acephate, and malathion--were selected both because they have been proven to be effective in grasshopper control programs and because their toxicity to mammals is relatively low. All three have been extensively tested in the field, and the effects of each have been well documented in the scientific literature. In addition, each of the three chemicals has been approved by EPA for use on rangelands. Two primary methods of application would be used in grasshopper control: ultra-low-volume (ULV) aerial spraying of all three chemicals and aerial application of carbaryl bait. In addition, carbaryl baits could occasionally be applied by ground equipment. The methods of application and the chemicals that would be used, as well as the means by which the chemicals would be selected for particular control programs, are described in the following sections.

Ultra-Low-Volume Aerial Application

The ultra-low-volume application of pesticides involves the application of less than 5 liters per hectare (0.5 gallon per acre) of spray liquid (Maas and Zindel, 1974). Very small droplets of spray liquid are produced, which often requires the use of special formulations of pesticides. The amount of insecticide that an aircraft using ULV spray techniques can carry is adequate to cover a larger area, thus reducing the time needed to treat a given area. This is an important advantage when large areas are to be treated, as is typical in grasshopper control operations. Another advantage of this application method is that the efficacy of ULV sprays in controlling grasshoppers is equivalent to conventional methods; thus, smaller amounts of insecticide active ingredient can be used. This reduces the cost of both chemicals and application, as well as the potential environmental impacts.

To achieve adequate coverage with small amounts of applied liquid, very small droplets must be produced. Small droplets increase volatilization and spray drift, so proportionally more insecticide may travel offtarget and may travel farther offtarget than when using conventional application techniques. The smaller amount of active ingredient used for ULV application can serve to balance this disadvantage, however.

Aerial application of ULV sprays for grasshopper control involves the use of fixed-wing aircraft operated by specially trained and certified pilots. Operations are conducted in accordance with program guidelines effective at the time of the operation, including the current APHIS Grasshopper Program Manual and the Aerial Application Manual. Operational procedures outlined in table 2-1 would also be followed. In general, aerial applications are conducted as close to the ground as possible to minimize drift. In grasshopper control, application aircraft typically fly at a median height 1 to 1.5 times the aircraft wingspan above the target. In a typical large operation, numerous personnel are directly involved; these personnel could include a representative of the APHIS contracting officer, an airstrip supervisor, a timekeeper, scouts to delimit treatment areas and identify nontreatment areas, one or more flaggers to operate guidance markers, a Plant Protection and Quarantine (PPQ) pilot, and an aerial application observer, as well as contractor personnel (including pilots, loaders, and the like).

Before any program is carried out, the area to be treated is clearly delineated on maps, and all personnel are made familiar with the planned operations. When existing landmarks are not adequate to delineate the area, electronic guidance markers, scouts, or flaggers are used to identify the

treatment area boundaries and to identify any areas that are not to be treated. If extensive areas are to be treated, more than one aircraft may be used, and plans and assignments are made to minimize the possibility of collision.

Mixing or other formulation preparation and loading are carried out at the airport or airstrip. Insecticides are actually applied by means of special nozzles on spray booms, which are mounted near the trailing edge of the aircraft wing. Aircraft spray equipment is calibrated, based on field tests performed before (and occasionally during) the operation, in order to ensure even and adequate distribution of droplets. Swath widths can range from approximately 75 feet to about 250 feet or more, depending on the size of the aircraft and other factors. Swath width is also calibrated in field tests.

The results of aerial application are thoroughly checked daily to determine whether all areas have been treated satisfactorily or if retreatment is necessary in some areas. (APHIS will retreat after an interval of 4 weeks, if necessary.) If insecticide applied to an area cannot be checked visually, appropriate liquid-sensitive dye cards can be used to determine the uniformity and adequacy of the application.

In some circumstances, weather conditions will make aerial application inappropriate because conditions could either reduce the effectiveness of the operation or cause substantial offtarget drift or both. For these reasons, weather conditions are also monitored by onsite inspectors before and during operations. When conditions that are not favorable for aerial application exist or arise, operations are postponed or interrupted. For example, operations are not conducted when winds exceed 10 miles per hour[1/] (because of the increased potential for spray drift), normally when temperatures exceed 80 °F (because of the increased potential for volatilization and thermal inversion), or when rain is falling or is imminent (because of the increased potential for pesticide runoff). In addition, areas containing crops for which the pesticide is not registered, areas where certain endangered or threatened species occur, and designated buffer zones around bodies of water, schools, recreational areas, and other sensitive areas are not treated.

[1/] In States where wind speed limitations are more restrictive, APHIS complies with those State regulations. Idaho State regulations, for example, allow spraying only when winds are less than 7 miles per hour.

Operational procedures that will be followed during ULV spraying operations are outlined in table 2-1. More detailed information concerning many of these procedures and measures may also be found in the guidance manuals for the grasshopper control program, including the APHIS Grasshopper Program Manual and the Aerial Application Manual. Assumptions concerning operations under various scenarios used in the evaluation of potential impacts in this EIS are described fully in chapter 4 and in appendix B.

Chemical Bait Application

The use of baits that have been treated with insecticide (either chemical or biological) involves the application of wheat bran baits using fixed-wing aircraft or, in some cases, mechanized ground-based equipment. Many of the same general practices used in ULV spray application, such as aircraft and facility selection, communications, and guidance markers, apply to aerial application of baits. The primary difference is in the insecticide handling and application equipment. All treatment programs would follow the guidelines in the APHIS Grasshopper Program Manual and the Aerial Application Manual.

Specific equipment requirements for bait application are outlined in table 2-1 and described in more detail in the Grasshopper Program Manual. For bait application operations, personnel are required to fill the same roles as described for ULV spray operations. In typical operations, baits are mixed (if necessary) and loaded at the airstrip or airport. Each aircraft load approximates the amount required for a specified number of swaths; this assists in achieving full treatment coverage. On leaving the aircraft hopper, bran bait passes through a spreader that has vanes or other devices to produce uniform deposits over the swath width. Trays are placed on the ground across the expected swath width. These trays collect bran and allow the dispersal system to be checked and calibrated at the beginning of a program and occasionally thereafter to ensure even and adequate distribution of bait.

In general, aircraft operate at heights similar to those in ULV spray operations, about 1 to 1.5 times the aircraft wingspan. Swath width approximates the wingspan, and off-target drift is minimal. Baits are not applied when it is raining or when rain is imminent, and untreated buffer zones are maintained around certain areas. These no treatment areas and other operational procedures that would be followed by all program personnel are shown in table 2-1.

The primary advantages of bait formulations are that they are highly selective for grasshoppers and use lower rates of toxicants than chemical sprays, and most economically important species of grasshoppers are susceptible (Onsager, 1986a).

This makes baits especially suitable in areas where potential impacts on nontarget organisms are of particular concern. There is also no significant problem with offtarget drift when using bait formulations, so baits can be applied with more precision than can ULV sprays. In addition, bait applications leave a surviving reservoir of grasshoppers for beneficial organisms that prey on them, and baits can be used under weather conditions that would preclude the application of chemical sprays.

Chemicals Considered for Use by APHIS

This section briefly describes the three insecticides under consideration for controlling grasshoppers and Mormon crickets. Table 2-3, located at the end of this chapter, shows the trade names, methods of application, and rates of application proposed by APHIS for carbaryl, acephate, and malathion. These application rates provided the basis for estimating the potential exposure of humans, wildlife, and other nontarget organisms to these chemicals. Each of the selected chemicals is briefly described below. (See the glossary for definitions of technical terms.) Detailed descriptions of the environmental fate and transport and the toxic properties of the chemicals are found in chapter 4 and appendixes A and B.

Carbaryl. Two methods of carbaryl delivery, aerial broadcast spray and aerial- or ground-broadcast bait, are considered in this EIS for controlling grasshoppers and Mormon crickets. In both cases, carbaryl insecticide is the active ingredient. The carbaryl formulation marketed as Sevin 4-Oil is used as an aerial spray at an application rate of 0.5 pound of active ingredient plus 4 fluid ounces of diesel oil per acre. Depending on the results of efficacy tests, expected to be completed in 1987, Sevin XLR Plus may be used in future years (at the same application rate). Carbaryl bait, either currently marketed baits or baits consisting of flaky wheat bran mixed with Sevin 4-Oil, is also used. Ten pounds of bait per acre containing 5 percent active ingredient (.5 pound of active ingredient per acre) is the application rate examined in this alternative.

Carbaryl is the common name of the insecticide 1-napthyl N-methyl carbamate and is used in numerous formulations under many different brand names. Technical grade carbaryl is an essentially odorless white crystalline solid. Carbaryl was first used in the United States in 1958 and is a broad-spectrum insecticide used to control a wide variety of insect pests on crops, pastures, rangeland, ornamental and lawn plants, and indoors. Carbaryl's action in killing insects comes from both contact and "stomach action" (that is, ingestion of vegetation on which carbaryl residues are present), and it has been widely used by private applicators, and

Federal, State, and local governments for pest control. Among the many other major programs in which carbaryl has been used are the treatment of large areas for gypsy moths and treatment for spruce budworms.

The data that are available on the environmental fate of carbaryl show that it is relatively nonpersistent. On plants, carbaryl levels decrease through photolysis, hydrolysis, and, to a lesser extent, through uptake into the plants. The length of time that carbaryl remains effective depends to a large degree on the formulation used; for example, Sevin 4-Oil has been shown to be relatively resistant to removal by rainfall (Union Carbide Corporation, 1973). In soil, carbaryl may be degraded by fungi. Its half-life in aerobic soils is approximately 7 days, in anaerobic soils, 28 days.

Carbaryl is rapidly excreted by animals, primarily in urine. In general, carbaryl demonstrates low to moderate mammalian toxicity, low toxicity to birds, and moderate toxicity to fish. It is extremely toxic to aquatic invertebrates, as well as to many terrestrial insects.

Although carbaryl spray is effective as a contact insecticide (that is, direct application to a grasshoppers' surface), its contact toxicity is lower than many other insecticides (McKinlay and Burrage, 1977). However, its ability to kill grasshoppers and Mormon crickets through ingestion of vegetation with carbaryl residues allows it to remain effective for at least 21 days. At the higher application rate of 1.0 pound of active ingredient per acre (1.0 lb a.i./acre), Onsager (1978) reported that Sevin 4-Oil caused extensive grasshopper mortality for approximately 21 days after application. At 0.5 lb a.i./acre, mortality increased over time after application, with mortality of third instar nymphs reaching 85 percent by the 21st day after application and mortality of fourth and fifth instar nymphs reaching 95 percent. In another field test, aerial application of carbaryl in a formulation identical to that proposed in this EIS reduced the number of grasshoppers by 29 percent after 2 days; mortality increased to approximately 64 percent by 5 days, 79 percent after 10 to 11 days, and 84 percent after 25 to 26 days (Foster et al., 1982). At rates lower than those proposed in this EIS, carbaryl is less effective as a spray; in a field test, for example, Mukerji and Ewen (1984) found that it was not effective on grasshoppers as a spray at rates below 0.21 lb a.i./acre.

Carbaryl baits have also been found to be effective in reducing populations of grasshoppers and Mormon crickets. As noted above, 10 pounds of bait containing 5 percent carbaryl (that is, 0.5 lb a.i./acre) is the formulation and rate

analyzed under the chemical control alternative. Foster et al. (1979) found that application of carbaryl bait at this rate for Mormon cricket control resulted in nymphal mortality of 90 percent and adult mortality of 94 percent 96 hours after treatment. Baits are currently marketed with 5 percent carbaryl, with labels calling for 20 to 48 pounds of bait per acre (1.0 to 2.4 lb a.i./acre).

Malathion. Ultra-low-volume aerial application of malathion for controlling grasshoppers and Mormon crickets is being considered in this EIS. Malathion is usually applied at a rate of 8 fluid ounces (0.58 pound) of active ingredient per acre. Any of several ULV formulations (which would typically range from 91 to 95 percent active ingredient) could be used on particular sites, depending on the results of competitive bidding.

Malathion is the common name of O,O-dimethyl phosphorodithioate of dimethyl mercaptosuccinate. A broad-spectrum organophosphate insecticide, malathion was first used in the United States in 1950 and is currently used to control a wide variety of insects on beef cattle, grain and vegetable crops, forests, pastures, rangelands, and in homes and gardens. Like carbaryl, malathion has been used in several major insect control programs, including programs for spruce budworms and the Mediterranean fruit fly.

Malathion is relatively nonpersistent in soil, water, plants, and animals. In soil, malathion is readily degraded by enzymes and by hydrolysis (under alkaline conditions). Its half-life is generally less than 1 day. It is unlikely that significant leaching of malathion could occur before degradation; adsorption by clays and the relatively low-moisture content of soils in most treatment areas would make leaching unlikely. In water, degradation occurs by both biological and chemical means, and the half-life is generally less than 48 hours. In plants, malathion residues persist from 21 hours to 5 days; insignificant amounts of malathion remain after 1 week. Because of the low volatility of malathion, it is transported in the atmosphere primarily by drift during application and does not transfer to the atmosphere after deposition. The products of malathion degradation include malaoxon, alpha and beta monoacids, a diacid, and other compounds. In general, the half-lives of the degradation products are somewhat longer than that of malathion itself.

Malathion does not bioaccumulate in animals; it is rapidly excreted after exposure ceases. It is moderately toxic to mammals, moderately to slightly toxic to birds, and moderately to highly toxic to some fish species and other aquatic organisms. Malathion is highly toxic to most insects, including bees. As with the other chemicals used for grasshopper

control, various operational procedures or mitigation measures are intended to reduce potential impact on nontarget areas and organisms.

Malathion has been found to be very effective in grasshopper control. Malathion can significantly reduce grasshopper populations within a very short time after application. While carbaryl at low application rates (0.5 lb a.i./acre) takes up to 21 days to be most effective in reducing grasshopper populations, many studies have shown malathion to be effective almost immediately. In field trials, 0.83 lb a.i./acre of malathion caused more than 85 percent mortality after 10 hours (Sokhta et al., 1983). Skoog et al. (1965) found that 0.75 lb a.i./acre led to 80 to 97 percent mortality, and Onsager (1978) found that 0.49 lb a.i./acre caused 87 to 92 percent mortality in adult grasshoppers from 1 to 2 weeks after treatment.

Several other field studies have also shown that malathion causes relatively rapid declines in grasshopper populations; little residual action was observed, however. Foster et al. (1982) found that grasshopper populations declined by more than 80 percent within 2 days after application and peaked at 86 percent after 5 days. At an application rate similar to that considered in this EIS (0.5 lb/acre), Foster et al. (1985) showed immediate effects but no significant increase in grasshopper mortality between the second and sixth day after application: mortality reached almost 95 percent after 2 days and over 96 percent after 6 days. Pfadt et al. (1970) reported residual activity of ULV malathion for 4.5 to 5.5 days on grasshoppers fed treated vegetation.

Malathion is also effective for Mormon cricket control. In one operation, aerial application of 8 fluid ounces per acre of ULV malathion (the same considered in this EIS) resulted in an 85-percent reduction of all cricket nymphs in 24 hours and a 95- to 99-percent reduction in 72 hours (USDA, 1973).

Acephate. Ultra-low-volume aerial broadcast application of acephate for the control of grasshoppers is being considered in this EIS. However, because acephate's efficacy in controlling Mormon crickets has not been tested, the use of acephate for the control of Mormon crickets is not being considered in this EIS. In grasshopper control, the Orthene 75S formulation would be used at an application rate of 0.094 pound of active ingredient in 32 ounces of water, plus an antidrift additive such as Orthotrol or Nalcotrol made of polyacrylamide-acrylic acid polymers (at 9 fluid ounces per 100 gallons of mix), and unsulfured molasses (at 3 percent of the total volume).

Acephate is the common name of O,S-dimethylacetylphosphoramidothioathe and is a white crystalline solid with a very low vapor pressure (2×10^{-6} mm Hg at 25 °C) and a very high solubility in water (65 percent). Acephate is a broad-spectrum organophosphate insecticide registered for use on grass, shrubs, trees, cotton, several grain and vegetable crops, pastures, and rangelands.

In soil, acephate is readily degraded through biological activity, with a half-life of about 11 days (in soils with moisture levels and organic content comparable to those in the West and Midwest). Although acephate is mobile in soil water and is easily leached, its degradation products (except for methamidophos--discussed below) are not susceptible to leaching. In laboratory studies, acephate's half-life in water is relatively long, particularly at cool temperatures and low pH levels; at pH levels of about 7, its half-life ranges from 16 to 47 days. In the field, its half-life in water and in bottom sediments is much shorter and may be as low as 1 day to a few days. About 5 to 10 percent of acephate degrades into methamidophos, which is itself a registered insecticide. As noted, methamidophos is readily degraded in soils (half-life 1.9 to 6.1 days), and its half-life of 2 to 6 days in water is comparable to, or slightly lower than, the half-life of acephate.

Acephate demonstrates low to moderate toxicity to most terrestrial and aquatic animals (excluding insects, for which it is highly toxic), including mammals. However, methamidophos is 10 to 70 times as toxic as the parent compound. Both acephate and methamidophos are relatively rapidly excreted in urine by mammals, and recovery from sublethal doses of acephate by most animal species occurs in a relatively few days. Acephate is highly toxic to most species of insects, including honey bees. Many of the operational procedures in table 2-1 have been designed to reduce any impacts that acephate could have on nontarget organisms and the environment. Specific procedures have been included to protect sensitive areas, bees, nontarget areas, endangered or threatened species, and humans.

Foster (1980) reviewed several field trials in which the efficacy of acephate for grasshopper control was tested. It was concluded that Orthene at low doses (0.031 and 0.063 lb a.i./acre) can result in satisfactory control under ideal rangeland conditions, particularly when molasses is added as a feeding attractant. Under actual conditions, a rate of 0.094 lb a.i./acre was recommended for use. Molasses, when included as a feeding attractant, increases the grasshopper mortality in the days immediately following application; thus, the inclusion of molasses allows acephate to be more effective sooner. Without molasses, the use of acephate at 0.094 lb

a.i./acre resulted in grasshopper mortality up to 92 to 94 percent after 10 days. With molasses, mortality exceeded 90 percent within 4 days.

Selection of Chemicals and Timing of Application

Under the chemical control alternative, APHIS would continue to respond to requests to treat economically important levels of grasshopper infestation. A population density that exceeded the economic threshold of approximately eight adult grasshoppers (or about 12 third-instar nymphs) per square yard would qualify an area for treatment. APHIS recognizes other factors, such as species composition, condition of the range, and cooperator concerns over the cost of the program, in determining whether an infestation has reached an economic threshold. Normally, treatments are not conducted unless the populations are two to three times this figure.

To a large degree, the selection of a particular chemical in a particular situation would depend on the time of year (that is, the stage in the grasshoppers' life cycles) and on economic and environmental considerations. For several reasons, it is seldom possible at present to predict with any accuracy where outbreaks will occur until grasshoppers reach at least the third nymphal instar. First, the probability of a catastrophic population reduction (resulting from meteorological or other conditions) declines rapidly after grasshoppers reach the third instar stage. Second, the third instar is the first to consume significant amounts of forage. Third, the emergence of the third instar often coincides with the maturation of important forage grasses and forbs, and thus any forage consumed thereafter will not be replaced by new growth (Hewitt, 1977). Because various important grasshopper species hatch at slightly different times, any location where an early prediction of an infestation is made (that is, when grasshoppers are predominantly third instar) would contain grasshoppers in various stages of development, ranging from egg to adult. Some time is needed to initiate a control program after it has been determined that control is necessary, and during that time the grasshoppers will be progressing through their life cycles and consuming forage at an increasing rate. For all these reasons, a control program aimed at grasshoppers in early stages of their life cycles (by the third instar) is more economical and effective than the same program applied later.

Chemical controls must be applied before egg-laying begins to prevent reinfestation for the next season. Assuming an infestation is identified at the third instar stage, a total of about 21 days is generally available for chemical control tactics, provided an infestation is comprised predominantly of a single species or of species that develop at approximately

the same time during the season. As infestations become heterogeneous mixtures of species that develop at progressively divergent times during the season, the earliest and latest stages progressively overlap and the window for control becomes progressively narrower.

In early season spray programs (beginning when the majority of grasshoppers are in the third instar), carbaryl may be the chemical of choice. Although more costly on a per-acre basis than either malathion or acephate (Foster, 1980), carbaryl is effective at lower temperatures than malathion and is effective for a much longer period of time--grasshopper mortality increases for approximately 21 days, as previously described. Thus, a potential outbreak could be detected while grasshoppers were predominantly third instar nymphs, the application of carbaryl spray could occur during the fourth nymphal instar stage, and adequate control could still result before most egglaying occurs (each of the five nymphal stages lasts 5 to 10 days and egg-laying occurs 7 to 14 days after adults emerge). Its residual effect also could provide control of grasshoppers that were in the first or second nymphal instar stages at the time of application and of late-emerging species. In addition, carbaryl may be used later in the season in higher elevations.

Malathion, on the other hand, may be preferred later in the season (when the majority are in the fifth instar). At those times, immediate control would be called for because most grasshoppers would be adults by the time controls were applied and the prevention of further forage destruction would be a high priority. Malathion's cheaper cost relative to carbaryl (that is, its cost per acre of application) also makes it more appropriate when carbaryl's residual action would not be an important consideration.

Acephate would be appropriate for mid- to late-season programs. It appears to be comparable or slightly favorable to malathion in cost; it is also comparable to malathion in effectiveness (Foster, 1980), although it takes slightly longer for maximum grasshopper mortality to occur.

The cost of carbaryl bait is comparable to malathion on a per-acre basis. In certain situations it could be the method of choice, particularly on or near environmentally sensitive or populated areas where the application of sprays and inherent drift problems could potentially cause adverse environmental or human health effects.

Environmental considerations would also be weighed in the selection of control methods. For example, if the area to be treated includes a crop for which one of the chemicals is not registered (which would require untreated buffer zones around

the crop), another chemical or nonchemical method would be preferable in that situation. If the area to be treated includes areas where ULV sprays could cause adverse impacts, carbaryl or Nosema baits might be the method of choice. Because all three chemicals used for ULV sprays are extremely toxic to bees, the presence of bees could affect the control method selected.

Table 2-1 lists operational procedures to be followed in the grasshopper control programs. Many of these procedures and methods, which are designed to reduce adverse impacts, do not apply to all control methods but only to one or several. The restrictions placed on each method by the operational procedures and by the label instructions for registered insecticides would also affect the selection process for individual areas.

Alternative 3 (Preferred Alternative)—Integrated Pest Management

In the early summer of 1986, an interagency technical work group was formed to initiate a long-term integrated pest management pilot project for grasshopper control. The interagency group included representatives of the Bureau of Land Management (BLM), National Park Service (NPS), and Fish and Wildlife Service (FWS) from the Department of the Interior; the Forest Service, Agricultural Research Service (ARS), Economic Research Service, Extension Service, and APHIS from the Department of Agriculture (USDA); and the Environmental Protection Agency (EPA). The IPM alternative described in this EIS has been developed to incorporate elements of the IPM pilot project for long-range programmatic consideration. The IPM Work Group has identified components of an IPM strategy that are currently available as well as those considered appropriate for further testing. APHIS has adopted this approach in its preferred alternative; as methods currently in research and development become operational, APHIS will conduct environmental analyses to supplement this EIS.

Integrated pest management is the selection, integration, and implementation of pest control tactics in a systems approach on the basis of anticipated economic, ecological, and sociological consequences. As implemented by APHIS, the selection of the IPM alternative would allow biological or chemical methods to be selected singly or in combination for immediate and long-term grasshopper control and would involve ongoing testing to identify other feasible control methods (including cultural/mechanical methods) that could be phased into future IPM programs. As the definition of IPM implies, the selection of a particular control method or combination of methods on an individual site would take into consideration several factors, including economic (the cost and the cost-effectiveness of various methods in both the short and long term), ecological (the impact on nontarget organisms and the environment), and

sociological (the acceptability of various IPM methods to cooperators, or the potential effects on land use).

As noted by several commenters during scoping, grasshopper control programs traditionally have relied heavily on suppressing grasshopper outbreaks after they occur. The primary means used for suppression has been insecticides. The primary aims of the IPM alternative would be to develop means by which outbreaks could be predicted and prevented and to develop alternative methods of grasshopper control (for both prevention and suppression) that reduce the use of chemical pesticides.

The following sections describe the methods that could currently be used in the IPM alternative and methods that may be undergoing further testing in the research and methods development components of ARS' and APHIS' programs. Finally, there is a discussion of the activities to be conducted under the first year of the IPM pilot project. Methods in testing in the IPM pilot project may be incorporated into the IPM alternative as they become available. Various factors that could affect the method selected on a particular site, including the timing of control, also are described.

Currently Available Chemical Control Methods

The same insecticides would be available for use under the IPM alternative as under the previous alternative, which proposed chemicals as the only control methods. These include carbaryl, malathion, and acephate ULV sprays and carbaryl bait (with 5 percent active ingredient). The total amount of chemicals used under the IPM alternative would be reduced in proportion to the acreage treated with nonchemical methods.

Currently Available Biological Control Methods

The use of biological methods to control grasshoppers and Mormon crickets involves the purposeful introduction of native and exotic natural enemies. These natural enemies could include fungi, bacteria, viruses, and protozoa, as well as parasites and predators. The only biological control currently registered by EPA and available for use is the microsporidean protozoan Nosema locustae.

Nosema locustae (Latin for "grasshopper sickness") is a naturally occurring protozoan parasite of many species of grasshoppers, including Mormon crickets. It appears not to affect other species of insects or any other plant or animal species. Henry and Onsager (1982) reported natural infection rates under 1 percent in test plots in Montana. In other samples taken in natural conditions in Idaho where Nosema

occurred, Henry (1972) found that it was present in about 5 percent of grasshoppers and that species varied in susceptibility. The most abundant species had the highest rates of infection. Infected grasshoppers were described as demonstrating slower rates of development and reduced mobility and as requiring a longer period for moulting. (Mormon crickets would presumably display the same responses.) Nosema is transmitted within existing populations by cannibalism brought on by overcrowding, and laboratory studies have shown that approximately 5 percent of the offspring of infected females are themselves infected (Henry, 1972). The optimal population density for transmission of Nosema is approximately 15 to 22 grasshoppers per square yard (Henry, personal communication, 1987). Once grasshopper population density declines to about two per square yard, Nosema is no longer transmitted efficiently (Henry, 1972).

Nosema is applied at a rate of 6 million to 1 billion spores per acre (one pound of bait per acre) for grasshopper control. The application rate for Mormon crickets is recommended to be twice this rate.

Large-scale field tests of Nosema as a means of grasshopper control have not shown consistent results, nor are they easily quantifiable (Wright, 1985). This is a result, at least in part, of logistical problems encountered during several of the tests. To date, tests of Nosema have attempted to suppress heavy infestations, so the experimental results probably represent a worst-case response to prevention efforts (Wright, 1985). Available data indicate that approximately 50 percent of infected individuals survive for 4 to 6 weeks (Henry et al., 1973). Because it is slower acting, Nosema is most effective if introduced in the early stages of an infestation or when an infestation is predicted. Observations in the laboratory indicate that dry material is needed in the diet of early instar nymphs. Thus, bran baits used with Nosema would be most accepted by the earlier instars present in an infestation being treated (third or fourth instars) (Onsager, 1987). Infected grasshoppers do not consume as much as uninfected individuals, and they are more vulnerable to predation and cannibalism, particularly during moulting; cannibalism further spreads the infection. Onsager (1986a) described two field experiments in which infestations treated with Nosema were abated over 1 or more years while untreated infestations remained high. Thus, Nosema shows promise as being effective in suppressing population levels in years following its introduction.

Ewen and Mukerji (1979) applied Nosema in one test at a rate of approximately 2 billion spores per acre (compared to approximately 900 million considered in this EIS). They found that from 20 to 65 percent of various species of grasshoppers

were infected. Mortality was not measured, but from 8 to 17 percent of nymphs in the following year were found to be infected with at least trace amounts. Field tests by Henry (1971) resulted in infection levels of 5 to 56 percent following treatments with Nosema.

Henry and Onsager (1982) concluded that Nosema could be "potentially useful" in an integrated control program. Wright (1985) stated that because of its relatively high cost per acre, Nosema would have high utility where environmental considerations were of primary importance. Nosema has only recently been marketed for grasshopper control on rangelands. It was first used as part of APHIS' grasshopper control program in 1986 after undergoing extensive research over the past decade or more. Limited production capacity constrained the amount available for use in 1986; in that year, APHIS funded treatments on approximately 25,000 acres with Nosema. The remainder (majority) of Nosema produced in 1986 was used in programs conducted by private groups. It is currently anticipated that production capacity in 1987 will be sufficient to allow Nosema to be used on a total of 1.5 million to 2 million acres. Within 3 years, production capacity should be adequate for treating 5 million to 6 million acres annually (Evans, 1986).

Selection of a Control Method--Factors to be Considered

The IPM alternative would allow APHIS' grasshopper control program to evolve as new techniques are proven feasible. Thus, the choices available could change from year to year. Of control techniques currently available for widespread application (that is, chemical methods and Nosema), chemicals are most cost-effective, but they have the potential for more adverse environmental impacts. In future years, as more methods become available, the IPM alternative would allow even more flexibility. As predictive models become more accurate, grasshopper control programs could become more prevention-oriented.

Chemical methods and Nosema would be available in the initial year(s) of an IPM program. As described under the chemical alternative, timing and relative cost-effectiveness would be important factors in the selection of the control method; other important factors would be the size of the area to be treated and the presence of sensitive areas within or near the area to be treated. Table 2-4 (at the end of this chapter) shows an example, based on typical conditions in Montana, of the time periods when current control methods might be appropriate (Onsager, 1986b). In other areas and under other conditions, the periods appropriate for the various methods could vary somewhat, but they would probably remain fairly

constant relative to one another (that is, baits and carbaryl spray would be most appropriate in the early season; acephate and malathion sprays later) (Onsager, 1986b). In sensitive areas, carbaryl baits or Nosema baits would be the method of choice as long as treatment occurs prior to the third or fourth instar. In cases where late season treatment is needed but species or resources sensitive to acephate, malathion, or carbaryl are present, treatment may not be possible.

As methods currently under consideration are phased into an IPM program in future years, the criteria for selection could be altered. Until more accurate information as to the efficacy, the cost-effectiveness, and the potential impacts of those methods is available, the extent to which the selection process would change cannot be described with any accuracy.

Potential Future Components of the IPM Alternative

As discussed in chapter 1, APHIS' grasshopper control program is supported by research (conducted by ARS) and methods development components. Ongoing research and testing on control methods that could ultimately be transferred into field use through the IPM pilot project is described in the following sections. Then, the objectives and tentative work plans for specific activities to be conducted in the first year of the interagency IPM pilot project are described.

Inflight Encapsulation. An alternative delivery method for chemical spray is being considered. In this method, a liquid consisting of a polymeric medium and chemical insecticide is sprayed from a nozzle by the same methods used for ULV sprays. Because of the attraction of the electrically charged particles, the polymeric medium in each droplet encapsulates the chemical. By being encapsulated, less chemical would be lost to volatilization, and thus less would have to be applied to treat a given amount of land. The microcapsules also would protect the chemical from washoff by rainfall and from degradation by sunlight or foliage enzymes. Chemicals delivered by inflight encapsulation would still be effective because microcapsules that reached forage would be consumed by grasshoppers along with the forage. Chemicals in unconsumed microcapsules would, through molecular diffusion, still be able to operate through contact action. Thus, for example, the period during which malathion is effective in killing grasshoppers could be extended beyond the 2 to 5 days during which mortality occurs from ULV spray alone.

Nosema. Varying rates and application times for Nosema will continue to be tested.

Carbaryl Bait. EPA has approved supplemental labeling for Sevin 4-Oil and Sevin XLR Plus to allow these insecticides to be mixed with wheat bran to make a bait for grasshopper and Mormon cricket control on pastures, rangelands, and wastelands. Application rates lower than 5 percent active ingredient have been found to be effective in tests. In tests where bait containing various levels of carbaryl were applied, grasshopper control increased as carbaryl rates increased (Foster et al., 1979; Mukerji and Ewen, 1984; Onsager et al., 1980). In one test, the maximum carbaryl rate was 0.18 lb a.i./acre, and grasshopper mortality reached almost 47 percent after 120 hours. In another test, 0.01 lb a.i./acre (0.1 percent of 1 lb bait/acre) resulted in 29-percent mortality of Mormon crickets after 4 hours; three successive applications resulted in 85-percent mortality in 36 hours (Onsager et al., 1980). In tests of a 2-percent bait, mortality increased as the amount of bait applied increased (up to 20 lb bait/acre) for Mormon crickets at a density of 30 per square yard. At 10 and 20 crickets per square yard, mortality was not significantly higher at 20 lb bait/acre than at 5 lb bait/acre (Foster et al., 1979).

The efficacy of several different formulations of carbaryl bait will continue to be assessed. The results of these tests would be used to determine recommended application rates in particular situations in the future.

Carbaryl/Nosema Bait Mixture. In certain situations, both carbaryl and Nosema baits or a single bait that carried both carbaryl and Nosema may be useful for grasshopper control. For example, if ULV sprays are inappropriate given specific site conditions, baits would be the delivery method of choice. If immediate control were necessary in such cases, carbaryl baits could be used; if longer-term control were also thought necessary, the use of Nosema bait could be appropriate, either applied in the same bait, in a separate application shortly after the carbaryl bait application, or in alternating swaths. However, the use of carbaryl/Nosema bait mixtures is not currently registered by EPA, and the efficacy of carbaryl bait followed by Nosema bait has not been adequately tested. For those reasons, the use of carbaryl bait followed by Nosema bait and the use of carbaryl/Nosema bait mixtures are not being considered as currently operational methods. Should either or both prove efficacious during testing, they could be included as operational methods in the future (provided all registration requirements were met).

Entomophaga grylli. *E. grylli* has been described as the most important fungal pathogen of grasshoppers and locusts (Dempster, 1963). It is said to play a significant role in the natural control of grasshoppers.

Grasshoppers infected with *E. grylli* typically show no outward signs for 4 to 8 days (Soper and Humber, 1982). Then, as amoeboid fungal cells begin to fill the body cavity, an infected insect becomes moribund and slows or stops eating. As death approaches, grasshoppers climb upward on vegetation and die while clinging to the vegetation. Spores are discharged from the dead insect and may begin a new round of infection if another grasshopper comes into contact with them.

The fungus affects many (perhaps most or all) species of grasshoppers and locusts throughout the world, and the two different strains of *E. grylli* apparently are lethal to different species (McDaniel and Bohls, 1984). No species of insect other than grasshoppers and locusts have been demonstrated to be affected by *E. grylli* in the 125 years since the fungus was first described, and there is no hazard to any vertebrate species (Soper and Humber, 1982).

Although early reports suggested that heavy rainfall or warm, humid conditions might be necessary for *E. grylli* to be effective, more recent data indicate that transmission and outbreaks can occur even under dry conditions (Soper and Humber, 1982). Reliable means have been developed for isolating strains of *E. grylli* in culture (MacLeod et al., 1980, as cited in Soper and Humber, 1982) and infection can be obtained from the injection of spores, from spraying spores in the field, or by confining grasshoppers on soil that contains spores. To date, *E. grylli* has not been artificially introduced into any naturally occurring grasshopper population in the field.

Entomopox Viruses (EPV's). EPV's are a group of pathogenic viruses with some potential as microbial agents of grasshopper control. These viruses have been isolated from a number of grasshoppers from North America and Africa (Oma and Henry, 1986). The viruses appear to be very similar structurally and fall into six basic groups. Each group infects certain species of grasshoppers. It may be possible in the future to enhance a particular group through recombinant DNA technology and thus enable EPV's to be used in grasshopper control.

Cultural/Mechanical Control Methods. Cultural/mechanical methods include various techniques of range management as well as the physical destruction of grasshopper eggs. Testing of the potential usefulness of range management techniques as a method of grasshopper control would involve the examination of the effects of livestock grazing practices and prescribed burning of grasshopper-infested areas.

According to Dyer and Bokhari (1976), there is some evidence that moderate grasshopper grazing can stimulate plant regrowth. In addition, some grasshopper species may be considered beneficial because they feed preferentially or exclusively on

plants that are unpalatable to livestock. However, there is no question that many species of grasshoppers can destroy range forage; Hewitt and Onsager (1983) have estimated that 21 to 23 percent of available rangeland forage is destroyed by grasshoppers annually.

The relationship between the abundance of important grasshopper species and the intensity of livestock grazing is extremely complex and not easily described. It is generally accepted that overgrazing opens up the plant canopy and improves the microhabitat for important pest species of grasshoppers through decreased relative humidity, increased temperature, and increased solar radiation. According to Smith (1940), the number of grasshoppers and the number of grasshopper species increase as mixed-grass prairies are overgrazed, particularly in dry years. These increases were said to be the result of changes in vegetation and habitat caused by overgrazing. Nerney (1958) stated that grasshopper population levels on short-grass rangelands were primarily a result of the condition of the range; the preferred habitat of economic species was described as being associated with poor rangeland with low-growing weeds. On fescue grasslands of Alberta, Holmes et al. (1979) found that the greatest numbers of grasshoppers were in areas with the heaviest grazing by livestock and that some grasshopper species showed population increases while others showed declines. It was concluded that the economic effects of grasshopper infestations could be compounded if high densities were combined with heavy grazing.

Capinera and Sechrist (1982) found a more complex relationship: the total number of grasshoppers was higher on ungrazed shortgrass prairie in Colorado and Arizona, but the grasshopper species complex changed as livestock grazing increased. It was concluded that it may be possible to modify grasshopper abundance by regulating grazing intensity, but such a change in abundance would be accompanied by shifts in the grasshopper species complex. Capinera and Sechrist (1982) suggested that grasshopper response is somewhat site-specific and may depend on the grasshopper species complex present, the host plants that are available, as well as the intensity of livestock grazing. Other related factors may also be involved. For example, Anderson (1964) found grasshopper populations were inversely proportional to plant height and amount of cover (that is, they generally were most abundant when both plant height and the amount of cover were low), which in turn can be influenced by grazing intensity.

Seasonal weather also may be an important factor in determining whether grasshopper populations reach levels requiring control, but the relationship is also complex. Dry weather has been implicated both in high (Smith, 1940) and low

(Nerney, 1958) grasshopper population levels. Warm, dry springs do facilitate grasshopper egg hatching, but they may prevent forage production sufficiently to keep grasshopper populations low. Cool, wet early-season weather, conversely, can reduce nymphal density but allow enough forage production to support large grasshopper populations.

It is clear that no single prescription exists that would allow any grazing management practice to result in predictable changes in grasshopper population levels. The Bureau of Land Management and the Forest Service are the Federal agencies that manage most Federal lands where grasshopper control programs are implemented. Descriptions of studies to be undertaken on the relationship between grazing systems and grasshopper populations in cooperation with these agencies is described in the section on the IPM pilot project.

The range management technique of prescribed burning as a means of preventing grasshopper outbreaks may also be examined in the future. One of the purposes of burning certain areas of rangeland would be to increase the amount of forage production in subsequent years. Prescribed burning can accomplish this, particularly if the desirable forage species is not in extremely poor condition (Peek et al., 1984; Seys and Bunnell, 1984). If the increase in forage production were not accompanied by a proportional increase in grasshopper populations, fire could lead to reduced competition between grasshoppers and livestock or wildlife. However, the relationship between prescribed burning and grasshopper populations is further influenced by the fact that burning can increase the palatability of plants to animals.

To the extent that burning caused changes in the relative abundance of rangeland vegetative species, the relative abundance of various grasshopper species also could change. This could occur both because many species of grasshoppers show definite preferences for individual species of vegetation and because of changes in the physical structure of the vegetation (Anderson, 1964).

It is not likely that prescribed burning would ever be practical on a large scale. It is clear that strict control of any fires would be necessary, and this would be difficult or impossible for extremely large acreages. Should future testing indicate that prescribed burning is a practical and effective means of grasshopper control, this range management method could be added to the IPM alternative in the future.

Other techniques of range management, such as the use of herbicides on range vegetation, scalping and furrowing, and seeding, may also be considered for further research in the future.

Egg Destruction. Another cultural/mechanical method suggested to be investigated under IPM is the possibility of reducing grasshopper density by destroying eggs. As early as 1922, it was recommended that in accessible areas where grasshoppers have deposited their eggs, the ground should be thoroughly plowed or disced and harrowed in the fall or early spring (USDA, 1922). Working the soil buries grasshopper eggs so deep that they cannot hatch and also brings eggs to the surface where they are desiccated by sun and wind (USDA, 1975). Tilling also makes the soil less attractive for egg laying. However, tilling in the arid West may result in wind or soil erosion.

It is unlikely that the destruction of eggs by working the soil would ever be practical on a large scale simply because of the large number of acres involved in grasshopper control. However, it could prove effective in smaller areas that are particularly susceptible to grasshopper egg laying, such as field edges, roadsides, and other weedy areas.

In addition, when large bands of grasshoppers or Mormon crickets have concentrated in relatively small areas at the time egg laying occurs, egg destruction could prove to be a practical means of preventing outbreaks the following year. Mormon crickets and higher elevation grasshoppers tend to lay eggs in more confined areas. Should testing indicate that egg destruction is useful in grasshopper control, the method could be added to the array of control techniques used in the future.

Data Base Development/Predictive Modeling. As described in chapter 1, sentinel site surveys are conducted to provide information on grasshopper population trends. The number and locations of the survey sites (1 to 4 or more) in each county to be surveyed are based on the county's history, the amount of rangeland in the county, the size of the county, and the accessibility of the site(s) by roads. Each season's sentinel sites are marked, and grasshopper populations are sampled at least three times at 2-week intervals.

The development of a data base from these surveys will assist APHIS in mapping species composition in given areas and in identifying relationships between outbreaks, the conditions or practices that trigger or accompany outbreaks, and various control methods. This, in turn, could prove extremely valuable in developing future control programs.

The following section on the IPM pilot project describes additional plans for data base development and predictive modeling.

The IPM Pilot Project

A budget of $3 million has been approved for the first year of the IPM pilot project. Staffing, equipment, and services will be supplied by each of the nine Federal agencies involved and through cooperative agreements with State universities.

The headquarters for the IPM pilot project will be in the BLM State Office in Boise, Idaho. It has been conceived as a 5-year demonstration project, although funding must be approved from year to year.

The objectives of the IPM pilot project are as follows:

(1) To refine an existing phenology model to maximize the efficiency of management activities.

(2) To demonstrate that early sampling can detect and classify incipient infestations that are amenable to management with alternative registered tactics.

(3) To develop economic thresholds and prescribe selective or nonselective treatments to reduce infestations to noneconomic levels with minimum effects on nontarget species.

(4) To quantify current-season and long-term responses of infestations following each available control tactic in order to support a model of population dynamics in response to treatments.

(5) To develop new selective methods for management of grasshoppers, including grasshopper virus and fungal pathogens.

(6) To provide for coordinated research on economics, range management, and ecology of nontarget species as components of a systems approach to grasshopper management.

(7) To integrate all pertinent data into one expert system that can be turned over to APHIS and private enterprise upon completion of the project.

Major aspects of the project will be accomplished at two demonstration sites in McKenzie County, North Dakota, and the Boise BLM District in Idaho. Alternative work sites will include Johnson County, Wyoming, and the Vale BLM District in Oregon. These demonstration sites represent the major ecosystems within which grasshopper outbreaks usually occur in the West.

Each demonstration site will include roughly 1 million acres. Testing of various management strategies and no-treatment sites (checks) will be conducted on infested acres. The no-treatment sites will be located outside the demonstration sites. A maximum of 100,000 acres per year may be treated in each demonstration site on as many as 10 different blocks. Treatment will be dictated by the phenological factors and will be in accord with the grazing use pattern for the particular area. One of the primary aims of this effort will be to test methods at their optimum period of effectiveness, rather than to be required to wait for a cooperator request before initiating treatment. Thus, the extent to which planned tests are actually implemented will depend on the occurrence of optimum infestation and climatological conditions.

Each method to be tested under the IPM pilot project for potential future use is described briefly below. As any control method(s) currently being considered prove suitable for future use in APHIS cooperative control programs, the potential impacts of the method(s) would be considered in a supplement to this programmatic EIS. For a method to be considered for incorporation into APHIS' cooperative program, it would have to have been adequately tested, registered by EPA (if applicable), commercially available, and approved by the IPM Work Group as ready for transfer from research and testing into field use. Those that are actually tested and accepted will depend upon funding available to the project, and they will be incorporated on a priority basis. Priorities will be assigned based on stage of development of the method and on those options that show the most promise (in terms of long- and short-term efficacy, environmental soundness, and the like) in initial testing.

In addition to testing control methods, other IPM pilot project components include environmental effects monitoring, posttreatment efficacy evaluations, range management, economic data collection, and data base development/predictive modeling. As the project progresses, the various components will be adjusted to fit particular needs. Data collection will be an ongoing function for the duration of the project.

The tentative first-year work plans for each of the components of the IPM pilot project are summarized in the following sections. As work plans are finalized, they will be available to the public on request. Work plans for future years will depend upon the direction taken and results of the first year.

<u>Inflight Encapsulation</u>. Under the IPM pilot project, APHIS will continue to test encapsulated Malathion CR at lower doses of active ingredient on 40-acre blocks. The operational

feasibility of this method may also be tested on larger treatment blocks.

Nosema. Under the IPM pilot project, Nosema will be tested at a rate of 1 billion spores per acre (1 pound of bait per acre). Assuming optimum infestation and climatological conditions arise to allow application during the optimum control window, Nosema will be applied on a maximum of 40,000 acres at two demonstration sites. APHIS will monitor for current season and continuing control at treatment sites over the 5-year period.

Carbaryl Bait. In the first year of the IPM pilot project, baits containing from 2 to 10 percent active ingredient will be used at an application rate of .5 to 1.5 pounds of active ingredient per acre. Again, assuming there are optimum conditions for treatment with carbaryl bait at the demonstration sites, approximately 40,000 acres will be treated at these rates.

Entomophaga grylli. ARS will continue its field search to find a strain of E. grylli that is amenable to reproduction in the laboratory.

Entomopox viruses (EPV's). In the first year of the IPM pilot project, ARS plans to develop a protocol for testing EPV's in the field.

Range Management. This component of the IPM pilot project will involve the cooperative efforts of the Bureau of Land Management, the Forest Service, the Idaho and North Dakota Agricultural Experiment Stations, and livestock producers. The objective of this work will be to quantify current-year and long-term responses of grasshopper populations associated with well-managed grazing systems and range improvements.

The first year of the range management component of the IPM pilot project will involve data gathering within the demonstration blocks to identify range conditions that are common to historical outbreak areas. Using this information, specific trial areas will be chosen to test range management options. Each trial area will include at least one grazing allotment. The number and location of trial areas will depend on actual infestation conditions and cooperative arrangements made with ranchers regarding the use of their allotments over the life of the project. The trial areas will be located far enough from private cropland to avoid the influence from chemical treatments on crops or cropland borders.

Trial areas will include vegetation in high and low seral stages and will preferably be located adjacent to sentinel weather stations. The following parameters will be sampled:

soil moisture, soil temperature, pore space, wetting front, surface area shaded, cryptogram cover, rock cover, basal area density, and soil organic matter.

Range improvement techniques that will be tested over the 5-year period for their long-term effect on grasshopper populations include the use of prescribed burns or the management of opportune wildfire, cultivation of specific vegetation species, and seeding of introduced species. In addition, livestock management techniques will be varied on trial areas to study their role in grasshopper control. Livestock management options to be tested include variations on timing of grazing use, intensity of grazing (numbers of livestock), and class of livestock. In addition, the relationship between grasshopper populations and numbers of antelope, elk, wild horses, or burros may be studied.

The successful implementation of this component will require the cooperation of participating ranchers over the 5-year period in terms of providing the appropriate number of livestock species during the prescribed periods, maintenance of needed facilities (to be constructed by APHIS), early coordination, and provision of the needed access to trial areas.

Based on the results of this study, ranchers and resource managers may be able to plan grazing systems that will lessen the impact of grasshopper outbreaks. As work plans for specific trials become finalized, they will be available from BLM or the Forest Service.

<u>Data Base Development/Predictive Modeling</u>. To date, limitations on the ability to predict grasshopper population increases and long-term effects of control strategies have hindered the success of rangeland managers in controlling outbreaks. Among the objectives of the IPM pilot project are (1) to refine the existing weather-driven phenology model to be better able to predict optimum control windows and (2) to develop a population dynamics model to predict population trends in the absence of or in response to treatments. An expert system for the management of rangeland grasshoppers is expected to require a substantial amount of knowledge based on the ecology and dynamics of the grasshoppers. This information, coupled with economic evaluations of their destructive potential, is critical for accurate decisionmaking. The data-gathering to be conducted under the IPM pilot project, which will improve APHIS' data base and predictive modeling capabilities, is described below.

A total of 9 to 15 data-gathering sites will be established within each of the two IPM demonstration blocks. Each of

these sites will contain a complete or partial weather-monitoring unit. Information gathered at each site would include data on weather; grasshopper species, development, numbers, and egg production; forage, including total yield, species, and condition; animal grazing use; environmental sampling; and economic data. (See the sections on environmental evaluation and economic research that follow for a description of data to be collected in the latter two categories.) Nine to 15 data-gathering sites will be established to collect weather and grasshopper information on two blocks in standard control programs adjacent to but outside of the designated demonstration blocks. In Idaho, 9 to 15 data-gathering sites will be established within a no-treatment block to gather similar data under no-treatment conditions.

In addition, sites representing each 1,000 to 1,280 acres treated under the pilot project will be established for pretreatment and posttreatment grasshopper counts.

Environmental Evaluation. The environmental evaluation component of the IPM pilot project consists of posttreatment monitoring for environmental effects of treatment and research on the effects of grasshopper control on migratory birds and other resources. The environmental evaluation aspect of the project has been developed in cooperation with the Fish and Wildlife Service.

Environmental monitoring to be conducted by Colorado State University in the IPM demonstration sites and near Dinosaur National Monument will include sampling for residues in water, sediment, aquatic insects, crayfish, and selected common species of fish before and after treatment; testing acetylcholinesterase levels in selected fish before and after treatment in treated and untreated areas; conducting laboratory bioassays to determine concentrations of chemicals associated with mortality, lordosis, and various brain cholinesterase levels in the same fish; determining the incidences of lordosis in larval and juvenile roundtail chub in the Green and Yampa Rivers before and after Mormon cricket control treatments; and determining the relative abundance of macroinvertebrates before and after treatment in waters in treated and untreated areas.

Environmental information gathered at the IPM demonstration sites, together with routine environmental monitoring data and sensitive area monitoring data (described in chapter 1), will be used to improve APHIS' ability to determine the environmental effects of its control programs and to refine operations accordingly.

Appendix C contains the detailed monitoring plan and sampling protocol to be followed in all APHIS monitoring programs (routine, sensitive area, and IPM).

Research on the effects of control treatments on migratory birds is also scheduled to take place in the first year of the IPM pilot project. The objectives of this research, which will be conducted by Colorado State University, are the following:

(1) To determine the impact on populations of nesting migratory birds inhabiting the interior of large chemical spray blocks (greater than 10,000 acres).

(2) To determine the degree of inhibition of acetylcholinesterase in birds inhabiting the interior, edges, and adjacent areas near large chemical spray blocks.

(3) To relate acetylcholinesterase inhibition to nesting productivity, survival, and emigration of migratory birds.

(4) To determine chemical spray buffer zone requirements to protect critical migratory bird habitats.

(5) To measure impacts on nestling growth and survival, adult bird foraging time, and food habit changes related to reduction in the insect food base.

(6) To determine relative pesticide exposure of nontarget migratory birds inhabiting large areas treated with liquid spray versus large areas treated with bran baits.

(7) To make direct observations of treatment impacts (if any) on the migratory bird species considered to have unstable or declining populations in U.S. Fish and Wildlife Service regions 1 and 6.

(8) To measure grasshopper predation by birds and other wild vertebrates and develop models of contribution to grasshopper control under different conditions and at different times of the season.

(9) To conduct a pilot study of acute oral toxicity of acephate and methamidophos to kestrels in the field.

In addition, research will be conducted to determine the mortality of wild vertebrates in relation to control treatments, and terrestrial and aquatic species samples will be collected and preserved for chemical analysis.

Economic Research. Another objective of the IPM pilot project is to develop economic thresholds that fit particular rangeland situations and prescribe treatments based on specific situations. In the first year of the IPM pilot project, the APHIS methods development program and the Agricultural Research Service will work to establish injury levels for different range ecotypes to refine APHIS' ability to assist cooperators in determining whether and how an infestation should be treated.

In addition, the USDA Economic Research Service, in cooperation with a university, will develop economic data to determine the cost-effectiveness and benefits of refined or new IPM treatment strategies. The objectives of this research are to estimate the impact of each alternative grasshopper control method on the following:

(1) Rancher costs and Federal program costs.

(2) Forage yield from range.

(3) Cattle ranch profitability and Federal program benefits.

(4) Onsite and offsite ecological/environmental values.

Finally, all the estimates of forage yield, ranch profitability, Federal program costs/benefits, and environmental values will be integrated into combined benefit-cost estimates for each alternative method studied. Both current season and long-term benefits will be considered. The data will be gathered on the IPM demonstration sites and analytical models will be used to simulate the economic implications for the alternative control strategies.

Number of Acres Potentially Affected by Grasshopper Control Methods

From 1972 to 1986, an average of approximately 2,049,000 acres was treated each year for the control of grasshoppers and Mormon crickets. (See table 1-1.) Annual acreages treated ranged from none in 1983 to 13,096,000 acres in 1985. On the average, approximately 11 percent of rangelands on which economically important populations of grasshoppers occurred were actually treated. This annual average is approximately 0.4 percent of total rangeland acreage.

The fluctuations in grasshopper populations and the factors that govern their levels and the extreme variation in the acreage treated annually in the past make it impossible to accurately predict the number of acres likely to be treated in the future. For the purposes of this EIS, however, it is assumed that the total area treated will remain at levels similar to those in the past but that control methods will evolve under the IPM alternative.

Operational Procedures and Mitigation Measures

A number of measures to increase the safety and reduce the impacts of APHIS' control program have been incorporated as operational procedures and mitigation measures for the alternatives being considered. The operational procedures would be a required part of programs funded by APHIS, while the mitigation measures are recommended for consideration at the site-specific level. The operational procedures are presented in table 2-1, while recommended mitigation measures are presented in table 2-2.

SUMMARY OF ENVIRONMENTAL CONSEQUENCES

Table 2-5, at the end of this chapter, summarizes the effects of grasshopper control methods on soils, vegetation, water, aquatic organisms, and wildlife. As described in chapter 4, grasshopper control activities are not likely to have significant impacts on air quality, noise levels, visual resources, cultural resources, or the use of public lands. Therefore, these elements are not included in table 2-5.

Table 2-6, also at the end of this chapter, summarizes the potential effects of grasshopper control methods on workers in APHIS' cooperative control programs and on the general public. APHIS has designed the operational procedures in table 2-1 to mitigate or avoid any action that might have significant adverse impacts on the human environment. All cooperators and APHIS personnel and contractors will be required to comply with these procedures. Given these procedures, no significant impacts on the quality of the human environment should result from any of the alternatives analyzed in this EIS.

Table 2-1--Operational procedures

ALL METHODS

1. Follow all applicable Federal, State, and local environmental laws and regulations in conducting grasshopper control operations.

2. Identify treatment areas in accordance with the APHIS Grasshopper Program Manual.

3. Hold public meetings well in advance of proposed programs. Arrange for public announcements to encourage public input into the decisionmaking process.

4. Notify Federal and State land managers and private cooperators of grasshopper infestations on their lands. This notification will describe estimated boundaries, severity of infestation, and optimal time frames for treatment. The notification will advise the land manager to advise APHIS of any sensitive areas (parks, recreation areas, and the like) that may exist in proposed treatment areas.

5. Obtain in writing land managers' and owners' requests that control be undertaken on their lands. When these requests originate as telephone calls, ensure that a followup letter is received before the expenditure of APHIS funds.

6. Except when treatments are mandatory under State law, avoid residences whose occupants object to their property being treated. When occupants object but State law requires treatment, APHIS will cooperate to the extent authorized by Federal and State law.

7. Endangered Species (see also the operational procedures listed under each control method).

    a. Formal and informal consultation with the U.S. Fish and Wildlife Service will be accomplished at the national level or designated contact points. (The Denver Regional Office has been designated as the official contact for formal consultation.) Communications with the Fish and Wildlife Service at the local level will be restricted to acquiring biological and distributional data for specific sites.

    b. APHIS has prepared a Biological Assessment on Federal endangered and threatened species for all States involved in its program. The Biological Assessment will be reviewed and updated as necessary on an annual basis. The measures designed to protect endangered and threatened species are contained in the Biological Assessment prepared by (and available from) APHIS and the Biological Opinion prepared by (and available from) the Fish and Wildlife Service.

    c. To protect peregrine falcon or bald eagle nesting sites, do not conduct any operations within 1 mile of those sites, and follow other protective measures agreed upon and documented through the conference and/or consultation process for proposed or listed species.

    d. State-listed endangered and threatened species, Federal candidate species, and other sensitive areas will be addressed in site-specific environmental assessments.

8. Instruct all program personnel on the use of equipment, materials, and procedures; supervise to ensure procedures are followed properly.

AERIAL BROADCAST APPLICATIONS (CHEMICAL AND BIOLOGICAL METHODS)

1. Strictly follow all EPA- and State-approved label instructions for chemical and biological insecticides.

2. Aircraft, dispersal equipment, and pilots that do not meet all contract requirements will not be allowed to operate.

3. All USDA APHIS Plant Protection and Quarantine (PPQ) employees who plan, supervise, recommend, or perform pesticide treatments must be certified under the APHIS Certification Plan. They are also required to know and meet any additional qualifications or requirements of the States where they perform duties involving pesticide use.

Table 2-1 (continued)--Operational procedures

4. Notify residents in treatment areas or their designated representatives at least 5 days prior to proposed operations. Advise them of the control method to be used, the proposed method of application, and precautions to be taken (for example, advise parents to keep children and pets indoors during ULV treatment).

5. Post flags or other markers in areas without landmarks such as highways, country roads, railroads, fences, utility lines, rivers, ridges, brush patches, buildings, and the like. Use flags or markers for pilot guidance on project boundaries and whenever precise applications are required and electronic guidance is not available. Mark blocks that are to be omitted from, or included in, the treatment area so they are visible from the air.

6. Provide two-way radios for all field personnel. Radio communication will be available for continuous contact among all units involved in any program.

7. Stock safety kits, thermometers, flagging material, wind gauges, spray-deposit samplers, and daily aircraft records in advance and make them available to relevant personnel.

8. No treatments will occur over congested areas. For all flights over congested areas, the contractor must submit a plan to the appropriate FAA District Office and the plan must be approved by that office; a letter of authorization signed by city or town authorities must accompany each plan. Where possible, plan ferrying and turnaround routes to avoid flights over congested areas, bodies of water, and other areas that are not to be treated.

9. Drum Disposal. All insecticide drums must be triple-rinsed before disposal. Rinse solution from drums may be used as diluent in preparing spray tank mixes, or it may be collected and stored for subsequent disposal in accordance with label instructions. One of the following methods for disposal must be used (listed in order of preference):

   a. Require chemical companies, distributors, or suppliers to accept the empty triple-rinsed containers.

   b. Transfer the empty triple-rinsed containers to State cooperators.

   c. Crush and/or puncture the empty triple-rinsed containers, report on Form AD-112 to Property Services, Field Servicing Office, Minneapolis, MN, and dispose of as scrap metal.

10. Conduct mixing, loading, and unloading in an area where an accidental spill will not contaminate a stream or other body of water.

11. In the event of an accidental spill, follow the procedures set forth in PPQ Guidelines for Managing and Monitoring Pesticide Spills (USDA APHIS, 1981).

12. Conduct prespray reconnaissance flights to ensure that pilots are familiar with program area boundaries, buffer zones, and any other areas that are not to be treated.

13. Notify local police and fire officials of pesticide storage areas and treatment blocks.

Baits (Chemical and Biological Methods)

1. Do not use blowers for loading bran baits into the hopper. (Blowers can cause packing of baits.)

2. The bait hopper must be dust-tight. It must empty completely with uninterrupted flow, and it must be vented to avoid erratic flow of materials.

Table 2-1 (continued)--Operational procedures

3. There must be a dust-tight gate in the hopper throat to avoid leakage during ferry flights, when flying over sensitive areas, and during turnarounds. Linkage between the gate and its cockpit control handle must be snug. Gate stops are required to ensure that the hopper gate is opened to exactly the same position each time: screw-type stops are preferred; stops that are adjustable through a series of holes or notches are not acceptable. The gate stop must be at the gate and not in the cockpit on larger aircraft.

4. For light applications, flow restricters are required in the hopper throat to reduce the rate of flow of materials and sensitivity of the control gate adjustments.

5. Carbaryl Bait.

   a. Protective clothing will be worn by all pilots, loaders, and field personnel, as required by the label.

   b. Do not apply within 200 feet of reservoirs, lakes, ponds, pools left by seasonal streams, springs, wetlands, and perennial streams and rivers.

   c. Do not apply within 500 feet of any school or recreational facility.

   d. Do not apply where the water table is high, where leaching or surface runoff is likely, or when precipitation is imminent.

   e. Do not apply within 200 feet or directly to oats, barley, and rye (fall treatments) and observe minimum days between final application and harvest for all other crops.

   f. Do not apply within 200 feet of commercial bee hives.

Ultra-Low-Volume Aerial Application (Chemical Methods)

1. To minimize drift and volatilization, do not use ULV sprays when any of the following conditions exists in the spray area: wind velocity exceeds 10 miles per hour (unless lower wind speed required under State law); rain is falling or is imminent; weather is foggy; normally when temperatures exceed 80 °F; air turbulence that could seriously affect the normal spray pattern; temperature inversions that could lead to offsite movement of spray.

2. Weather conditions on operation areas will be monitored by trained personnel before and during application. Operations will be suspended anytime it appears that weather conditions could jeopardize safe placement of the spray on target areas.

3. Do not apply when foliage is wet.

4. Do not apply chemical ULV any insecticide within 500 feet or directly to any crops for which it is not labeled, or to any crop for which no tolerance has been established, unless an exemption under Section 18 of FIFRA has been granted.

5. All APHIS project personnel will have baseline cholinesterase tests before the first application of insecticide and when deemed appropriate thereafter. It will be recommended that contract, State, and private project personnel also participate in a cholinesterase monitoring program.

6. Advise unprotected workers to stay out of treated areas until insecticides have dried.

7. Use nozzle types and sizes, spray system pressure, and nozzle orientation as specified in the APHIS aerial prospectus.

8. A vent for the insecticide tank, of sufficient size to permit unrestricted flow when a load is jettisoned, is mandatory.

Table 2-1 (continued)--Operational procedures

9. Do not spray while school buses are operating in the treatment area.

10. Protective long-sleeved work clothing will be worn by all pilots, loaders, and field personnel as specified in the label. For mixers and loaders of acephate, protective clothing must include impermeable gloves, long-sleeved shirt, and long-legged trousers.

11. Do not apply within 500 feet of reservoirs, lakes, ponds, pools left by seasonal streams, springs, wetlands, and perennial streams or rivers.

12. Do not apply where the water table is high or where leaching or surface runoff is likely.

13. Do not apply within 500 feet of any school or recreational facility.

14. Do not allow lactating dairy animals to feed or graze on grass hay that has been treated with acephate. Do not use spent mint hay that has been treated with acephate for dairy animal food.

15. Protection of Bees:

    a. If off-season or early-season planning indicates an area may require treatment, send early notification letters and maps to all registered apiarists in the State or near the area.

    b. Conduct prespray reconnaissance flights to ensure that all honey bees have been moved or protected. Should bees remain, ensure that the beekeeper received notice of the impending treatment or that programs are conducted in accordance with State law.

    c. If treatments are planned within 4 miles of areas where alkali or leaf cutter bees are being used (for increasing the yield of alfalfa seed), monitor wind conditions and other drift factors closely and do not apply ULV sprays when drift could reach these areas. In all such cases, use spray samplers (dye cards) near these areas.

    d. Do not apply acephate, carbaryl, or malathion to any blooming crops or weeds or allow it to drift onto blooming crops and weeds if commercial bees are visiting the area.

Table 2-2--Recommended mitigation measures

AERIAL BROADCAST APPLICATIONS (CHEMICAL AND BIOLOGICAL METHODS)

1. Provide local representatives of interested State and Federal wildlife agencies the opportunity to observe all segments of the program.

Ultra-Low-Volume Aerial Application (Chemical Methods)

1. When possible, apply sprays only during morning hours.

2. Application aircraft will fly at a median altitude 1 to 1.5 times the wingspan of the aircraft whenever possible.

3. Advise local law enforcement officials to divert traffic on major highways around spray blocks or to hold traffic on major highways until aircraft have completed treatments that could affect vehicles or travelers.

4. Protection of Bees:

   Prior to treatment, send a second notification by letter, personal contact, or public notification to all registered apiarists in or near the treatment area before treatment is to occur.

Table 2-3--Application information on currently available chemical control methods

Insecticide	Trade name/formulation	Active ingredient	Application method	Application rate1/
Carbaryl	Sevin 4-Oil2/	1-napthyl N-methylcarbamate	(a) ULV3/ aerial broadcast	0.5
	Sevin 4-Oil + Bran		(b) Bran baits: 5 percent a.i.	up to 0.5
Acephate	Orthene 75 S4/	O,S-dimethylacetylphosphoramidothioate	ULV aerial broadcast	0.094
Malathion	Cythion5/ Malathion ULV Concentrate5/ Prentox6/ Fyfanon7,8/	O,O-dimethyl phosphorodithioate of diethyl mercaptosuccinate	ULV aerial broadcast	0.58

1/Application rate in pounds of active ingredient per acre.
2/Registered trademark of the Union Carbide Corporation.
3/Ultra-low-volume application.
4/Registered trademark of the Chevron Chemical Company.
5/Registered trademark of American Cyanamid Company.
6/Registered trademark of Prentiss Drug and Chemical Company, Inc.
7/Registered trademark of A/S Cheminova.
8/Other ULV formulations (in concentrations over 90 percent active ingredient) may also be used.

Table 2-4--Example of time periods[1/] during which currently available chemical and biological control methods would be preferred

May	June	July	August
(--- Peak third instar)			
(--------- Nosema/Carbaryl Baits ------------)			
	(------------ Carbaryl Spray -----------------)		
	(---------------- Acephate Spray ------------)		
		(----- Malathion Spray -----)	

[1/] Time periods are based on average phenology in Montana. Periods may be shorter or longer in other areas, but relative order of methods should remain similar to that shown.

Table 2-5--Summary of environmental impacts

Effector	Soils and vegetation	Water and aquatic organisms	Wildlife
NO CONTROL	During heavy infestations, virtually all vegetation in the area would be threatened, and plant growth could be retarded for several years. Plant removal by grasshoppers would leave ground surface vulnerable to increased sunlight and rainfall. This could lead to serious erosion problems and disturbance of soil organisms.	Grasshopper consumption of vegetative ground cover could cause increased sedimentation and turbidity due to increased soil erosion. This would decrease photosynthesis of aquatic plants and reduce the productivity of the aquatic ecosystem.	Destruction of gresses and forbs during grasshopper infestations could retard plant growth for several years. Localized disruption of food and cover habitat for wildlife would result. In addition, overall numbers of animals and diversity of species could be reduced by direct mortality, reduced reproductive success, and emigation from the area. After full plant recovery, wildlife numbers and species could also be expected to recover.
CHEMICAL CONTROLS			
Carbaryl Bait	Under normal operating procedures, carbaryl bait should have no impact on soils. In addition, the nonphytotoxicity of carbaryl and the minimal contact of bran bait with leaf surfaces should prevent adverse effects to vegetation.	Adherence to operational procedures would prevent bait applications within 200 feet of bodies of water supporting higher aquatic life. Carbaryl bait would not reach water from drift. Thus, there would be no impacts on water quality or aquatic organisms under normal circumstances.	Carbaryl is slightly toxic to birds and moderately toxic to mammals. The only nontarget organisms at risk from carbaryl bait applications would be granivorous species that ingested bait flakes. In some cases, individual birds or mammals could receive doses adequate to cause toxic effects or death. Temporary cholinesterase (ChE) depression would occur when any animal ingested carbaryl bait. The reduction in the numbers of grasshoppers under any method could also affect wildlife species that feed primarily or preferentially on grasshoppers, but those effects could be offset as alternative food sources are utilized. There would be no impact on foraging honey bees.
Carbaryl Spray	Carbaryl is normally degraded to nondetectable levels in soil within less than 40 days. Therefore, carbaryl spray should have only minor impacts on soils or soil organisms. Densities of soil microorganisms could be temporarily affected but should return to pretreatment levels within a short period. Carbaryl is nontoxic to most plants when applied at label rates. Immediate reductions in grasshopper	Operational procedures call for a 500-foot buffer between treated areas and bodies of water supporting higher aquatic life. Thus, carbaryl would reach water only through spray drift. Under normal conditions, there should be no long-term effects to any species of aquatic organism due to the short half-life of carbaryl in aquatic environments. No fish or crayfish should be killed. Populations of aquatic	Carbaryl spray would reach nontarget organisms through direct application, through contact with vegetation containing carbaryl residues, or through ingestion of such vegetation. Depression of ChE levels and associated behavioral anomalies could occur in small mammals and birds after exposure to carbaryl. In addition, the petroleum oils in Sevin 4-Oil and the diesel oil used as a carrier for

Table 2-5 (continued)--Summary of environmental impacts

Effector	Soils and vegetation	Water and aquatic organisms	Wildlife
	populations would eliminate continued damage to rangeland plants. Petroleum and diesel oils used with Sevin 4-Oil would not have adverse effects on the soil or soil organisms or on vegetation.	insects could be reduced, particularly in streams, but any effects should be temporary. Programmatic and site-specific operational procedures and protective measures should reduce the likelihood that any critical habitat or endangered or threatened aquatic species would be adversely affected. In accidental situations, adverse impacts to aquatic environments could occur. If carbaryl were directly sprayed onto the surface of a reservoir, or if a thunderstorm and resultant runoff were to occur after spraying, some invertebrates and insect species would be severely affected. In an accident where 200 gallons of spray mixture was jettisoned into a reservoir, there would be fish kills and depletion of aquatic insects and invertebrates. Fish and aquatic insects would be killed by the jettisoning of a load containing diesel and petroleum oils. However, these situations are not expected to occur.	Sevin 4-Oil could affect the reproductive success of birds in treatment areas. Bees and other insects would be at risk from carbaryl spray; adherence to operational procedures that are intended to protect honey bees as well as alkali bees and leafcutter bees should minimize the impact. Populations of other insects, including wild pollinators, would be temporarily reduced. Local populations may be affected indirectly by loss of insect prey and lowered reproduction success; however, there should be no significant impacts on overall species populations. Programmatic and site-specific operational procedures and protection measures should minimize the possibility of adverse effects on any endangered or threatened species from any of the chemicals.
Acephate Spray	Acephate has a short half-life in soil (4-10 days) due to its high biodegradability. For that reason, only minor, short-term effects on soil organisms should occur. Acephate is nonphytotoxic and should not adversely affect vegetation. Destruction of rangeland plants would be minimized following reductions in grasshopper populations.	The risk analysis indicates that there should be no adverse effects on water quality or aquatic environments from the use of acephate in grasshopper control in routine or accidental situations. Operational procedures described above for carbaryl also would apply to acephate and these procedures should ensure that no adverse impacts would occur.	Impacts of acephate spray would be similar to those of carbaryl; because the application rate of acephate is lower than for carbaryl and because acephate is less toxic, the effects would be reduced. However, the acephate degradation product methamidophos could increase the risk of toxic effects in small mammals and birds, resulting in reduced ChE levels and related behavioral abnormalities.
Malathion Spray	Malathion is readily metabolized by soil microorganisms and undergoes relatively rapid chemical degradation in soils. No significant impacts on soil organisms should occur. Malathion is nonphytotoxic. Immediate reductions in grasshopper populations	Under normal operating conditions, most aquatic species would suffer no adverse effects from malathion sprays. Populations of some aquatic invertebrates would be reduced in the short term. Runoff from a heavy thunderstorm could result in population	Impacts of malathion spray on wildlife would be similar to those of carbaryl, but because malathion is more toxic to wildlife than carbaryl and because the application rate is slightly higher for malathion, any impacts would be greater. Overall

Table 2-5 (continued)--Summary of environmental impacts

Effector	Soils and vegetation	Water and aquatic organisms	Wildlife
	would curtail further destruction of rangeland plants.	reductions in aquatic insects and invertebrates. Direct fish kills could result if reservoirs are directly sprayed or if a 200-gallon load is jettisoned into a reservoir. However, operational procedures (as described for carbaryl) also would apply to malathion spray operations and should prevent significant impacts.	wildlife populations would not be seriously affected directly, but local populations may be affected indirectly by loss of insects as food or from behavioral changes that affect reproduciton or to escape predation.
BIOLOGICAL CONTROLS			
<u>Nosema locustae</u>	Although Nosema persists in soil, it has no effect on the soil or on soil organisms. Nosema is nonphytotoxic and does not affect nontarget insect species. However, because it is slower-acting, grasshoppers could cause further damage to rangeland vegetation before grasshopper populations are significantly reduced.	No impacts.	No impacts.

Table 2-6--Summary of impacts on humans

Effector	Workers	General public
NO CONTROL	No impact.	When heavy infestations occur, loss of forage would cause adverse economic impacts.
CHEMICAL CONTROLS		
Carbaryl Bait	No impact under normal conditions. In the case of spills onto skin and clothing during mixing of bran and Sevin 4-Oil, exposure to the concentrate could cause reversible neurotoxic effects.	No impact on public health. Reduction in forage loss would result in economic benefits.
Carbaryl Spray	No significant impacts under routine circumstances. An accidental spill on workers may produce severe but reversible neurotoxic effects (e.g., vomiting, abdominal cramps, diarrhea, dizziness). An accidental spill of diesel oil could cause severe skin irritation. Operational procedures would reduce	No significant health impacts are expected under routine or accidental circumstances. Maximum theoretical calculated cancer risk to the public through dietary exposure is 1.6 chances in 100,000. Reduction of forage loss would result in economic benefits. the likelihood of accidents.
Acephate Spray	No significant impacts under routine circumstances. An accidental spill on workers could produce moderate but reversible neurotoxic effects (e.g., headache, dizziness). Maximum theoretical calculated cancer risk to workers is 4.5 chances in 1 million. Operational procedures would reduce the likelihood of accidents.	No significant health impacts expected under routine or accidental circumstances. Maximum theoretical calculated cancer risk to the public is 3.8 in 10 million. Reduction in forage loss would result in economic benefits.
Malathion Spray	No significant impacts under routine circumsances. Accidents could produce impacts similar to those of carbaryl. Maximum theoretical calculated cancer risk to workers is 1.6 chances in 10,000.	No significant impacts are expected under routine or accidental circumstances. Maximum theoretical calculated cancer risk to the public is 5 chances in 1 million Reduction in forage loss would result in economic benefits.
BIOLOGICAL CONTROLS		
Nosema locustae	No impacts under routine or accidental circumstances.	No impacts under routine or accidental circumstances. Reduction in forage loss would result in economic benefits; if grasshopper population reductions extended to future years, economic benefits would continue.

Chapter 3
The Affected Environment

INTRODUCTION

The rangelands of the 17 western States and parts of Alaska are the environment potentially affected by the APHIS grasshopper and Mormon cricket cooperative management program. The most extensive and economically important rangeland areas are the grasslands and savannas of the Great Plains and Texas, the mountains and deserts of the west, and the annual grasslands of California (figure 3-1). These vast rangeland areas are a valuable natural resource providing grazing for domestic livestock, food and cover for a variety of wildlife species, and recreational resources for the public.

A significant threat to the animal productivity of these rangeland areas is the proliferation of grasshopper populations. Grasshoppers have been a serious pest in the western States and parts of Alaska since early settlement. Weather conditions favoring the hatching and survival of large numbers of grasshoppers can cause outbreak populations. The resulting damage to vegetation may be so severe that all grasses and forbs are destroyed and plant growth is retarded for several years. The consequences are reduced grazing for livestock, loss of food and habitat for wildlife, and soil erosion.

Programs to control economically damaging grasshopper infestations are conducted by APHIS and cooperating Federal and State agencies, as well as by private individuals. Table 3-1 shows the number of acres treated in the USDA APHIS program by State in 1985. Chapter 1 discussed grasshopper biology and the APHIS cooperative grasshopper management program.

This chapter describes the rangeland regions and resource categories that will be used in considering the environmental effects of the APHIS management program. The overview section presents a general description of the physical, biological, and cultural setting of the rangelands of the 17 western States.

The impacts of the APHIS management program may differ from one rangeland area to another in the western States and Alaska because of differences in physical characteristics, such as climate or ground-water supplies, or because certain biological elements, such as plant productivity or existence of endangered species, differ. To address these potential differences in the impacts discussion in chapter 4, the 17 western States and Alaska were partitioned into eight rangeland regions. The second half of this chapter presents

Source: Rand McNally Atlas of the United States. 1983. Rand McNally and Company, New York.

Figure 3-1--Physical features of the western United States and Alaska

Table 3-1--Grasshopper survey and treatments 1984-85

State	Acres infested (1984 adult survey)			Estimated acres requiring treatment based on adult survey			Acres treated - 1985			
	Private/State	Federal	Total	Private/State	Federal	Total	State	Private	Federal	Total
Arizona	822,000	2,258,000	3,080,000	0	500,000	500,000	--	--	65,163	65,163
California	0	0	0	0	0	0	--	--	--	0
Colorado	10,533,500	1,441,725	11,975,225	300,000	10,000	310,000	14,400	40,196	198,965	253,561
Idaho	1,577,757	3,102,800	4,680,557	300,000	1,200,000	1,500,000	332,400	570,009	5,530,181	6,432,590
Kansas	0	0	0	0	0	0	--	--	--	0
Montana	2,185,000	531,000	2,716,000	0	500,000	500,000	13,961	238,662	1,209,321	1,461,944
Nebraska	9,973,760	284,800	10,258,560	400,000	100,000	500,000	--	--	27,650	27,650
Nevada	35,940	39,860	75,800	0	0	0	--	--	--	0
New Mexico	7,795,000	627,000	8,422,000	400,000	100,000	500,000	--	--	--	0
North Dakota	552,804	422,396	975,200	200,000	350,000	550,000	44,809	236,945	368,804	650,558
Oklahoma	197,500	0	197,500	100,000	0	100,000	--	86,947	--	86,947
Oregon	654,600	1,028,640	1,683,240	300,000	200,000	500,000	18,260	111,702	364,988	494,950
South Dakota	1,338,840	624,440	1,963,280	300,000	500,000	800,000	1,360	76,349	11,889	89,598
Texas	3,698,913	0	3,698,913	500,000	0	500,000	--	45,872	--	45,872
Utah	1,798,320	1,123,700	2,922,020	100,000	300,000	400,000	110,188	156,030	1,073,355	1,339,573
Washington	92,000	68,000	160,000	35,000	35,000	70,000	927	15,137	240	16,304
Wyoming	2,110,960	791,340	2,902,300	800,000	300,000	1,100,000	301,944	2,329,793	322,279	2,954,016
TOTAL	43,366,894	12,343,701	55,710,595	3,735,000	4,095,000	7,830,000	838,249	3,907,642	9,172,835	13,918,726

Source: APHIS PPQ administrative data.

descriptions of those regions. The Delta Junction analysis region of Alaska is included in that section.

The overview of the general rangeland environment and the descriptions of each rangeland region cover the following characteristics and resource elements:

(1) Topography and Climate

(2) Soils

(3) Vegetation (both native and introduced plants, and agricultural crops)

(4) Terrestrial Wildlife (including endangered and threatened terrestrial wildlife species)

(5) Water Resources and Aquatic Life (including endangered and threatened aquatic species)

(6) Human Populations--particularly the populations potentially at risk in the APHIS grasshopper management program (workers and the general public)

(7) Land Uses and Cultural Resources

In addition, the overview provides a general description of the visual resources, air quality, and distribution of economically important grasshoppers in the rangelands of the 17 western States.

It should be noted that the 1987 Biological Assessment (USDA, 1987) lists all federally endangered and threatened species by county in areas in which treatments may occur. In addition, important endangered and threatened rangeland species are listed in the Overview and sections on individual analysis regions in this chapter.

OVERVIEW OF THE RANGELANDS OF THE 17 WESTERN STATES

Rangeland Characteristics

Rangeland environments are areas that are generally too dry for intensive agriculture or forestry. The potential natural vegetation is predominantly grasses, grass-like plants, forbs, or shrubs. Rangeland includes natural grasslands, savannahs, shrublands, most deserts, tundra, and alpine communities. These lands produce a significant portion of livestock for the country, as well as support grazing and browsing big game animals.

Most of the grazed range in the contiguous United States is located in the 17 States west of the Mississippi River (see figure 3-2). In Alaska, grazing lands are located primarily in the lowlands of the Yukon-Kuskokwim Basins and the Tanana Valley. In 1976, almost two-thirds of the 820 million acres of rangelands in the contiguous United States and Alaska were grazed. Of that acreage, two-thirds consisted of non-Federal range and the remaining third was federally owned. Most of the non-Federal grazed lands are in the prairie States. For example, 98 percent of the range grazed in the six Great Plains States is privately owned. Further west, Federal ownership is greater; and in the Pacific Northwest, Federal lands constitute more than one-half of the grazed range (USDA SCS, 1981).

Physical and Biological Setting of the Western Rangelands

Topography and Climate

The topography of the rangelands in the western States varies from the nearly level or gently rolling lands of the Great Plains to the steep and rugged regions of the Rocky Mountains. Elevations range from 280 feet below sea level in the deserts of California to more than 14,000 feet in the alpine habitats along the Continental Divide in Colorado.

The climates of the area vary from the temperate climate of the northern Great Plains, Upper Missouri River Valley, and intermountain regions to the hot climate of the southwestern desert regions. Annual precipitation on the rangelands varies from considerably less than 6 inches in southern Nevada and the Mojave Desert in California to more than 18 inches in eastern Oregon and Washington (see figure 3-3). This environmental setting affects soils, vegetation, and wildlife that are indigenous to individual areas as well as land use, socioeconomics, and human populations of the rangeland areas.

Soils

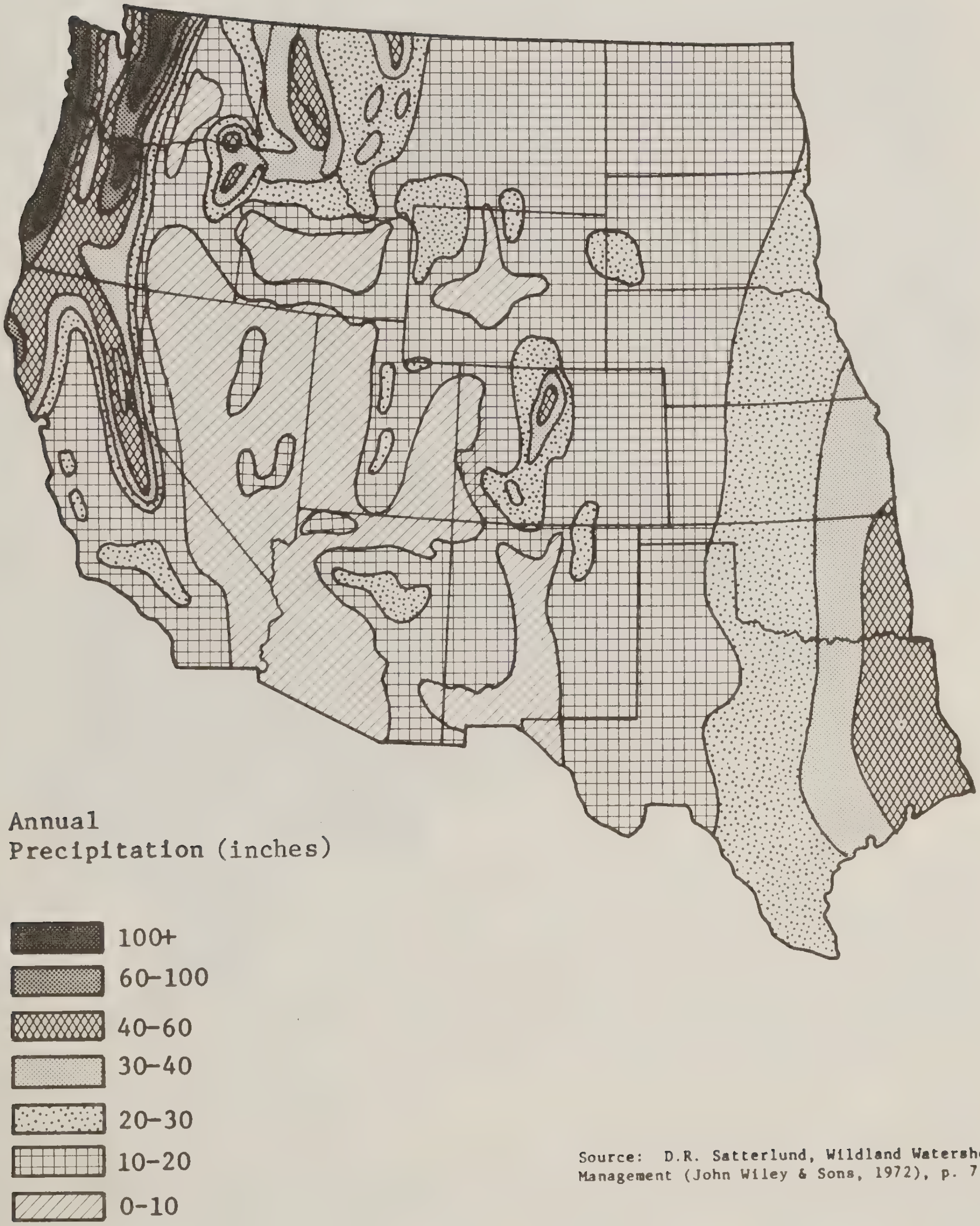
Seven major soil orders shown in figure 3-4 are commonly found in the western rangelands.

The <u>entisols</u> are mineral soils that lack significant soil layers. When adequately fertilized and when water supply is controlled, some of these soils are quite productive. However, depth, clay content, and water balance limit the intensive use of large areas of these soils.

The <u>vertisols</u> are mineral soils characterized by a high content of swelling-type clays that cause deep, wide cracks in the soil during dry seasons. There is extensive shrinking, cracking, and shearing of the land, which is thus generally unstable. The soil is sticky and plastic when wet, and hard

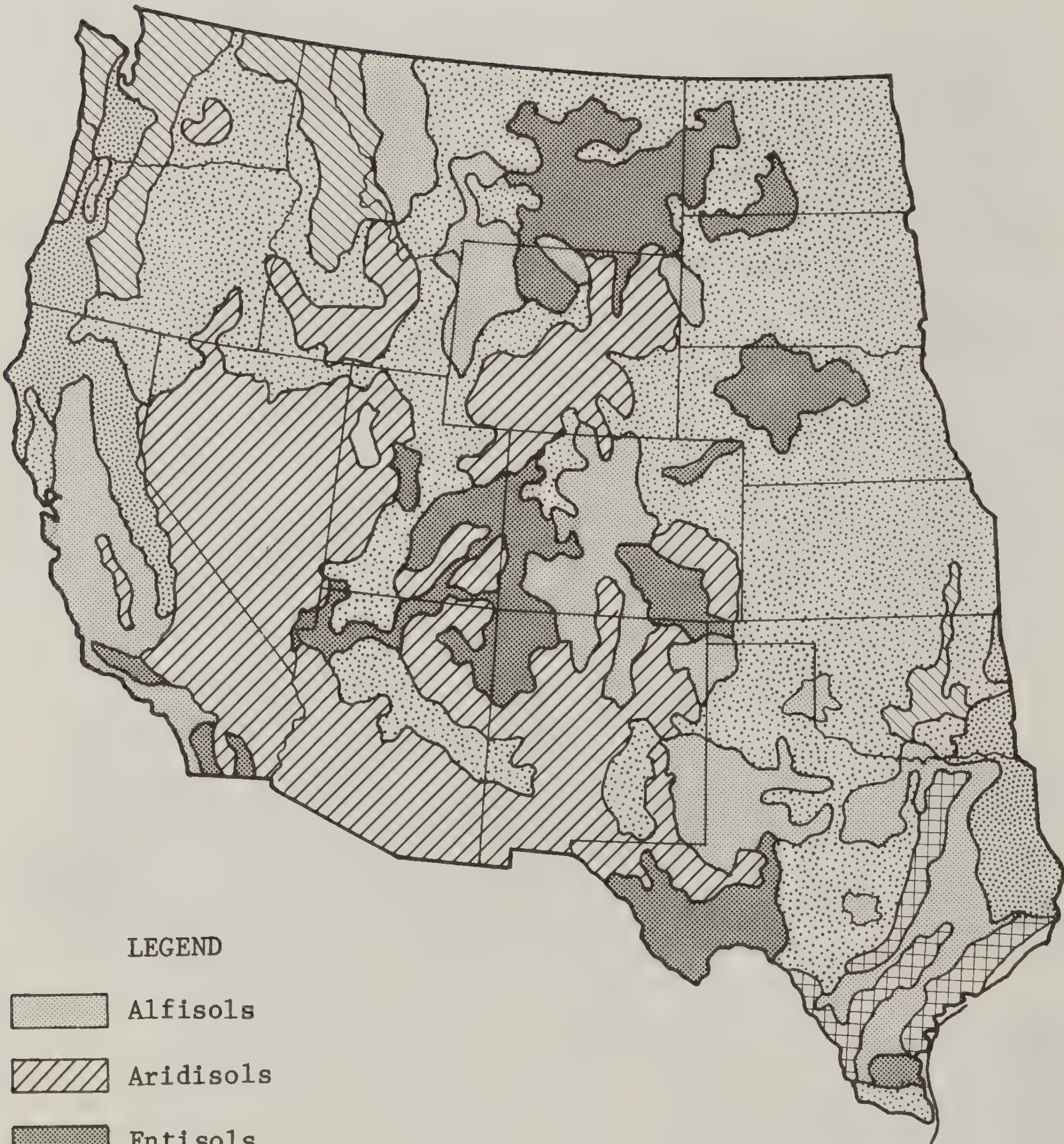
Source: U.S. Department of Agriculture. 1981. An assessment of the forest and rangeland situation in the United States. Forest Resource Report No. 22. Goverment Printing Office, Washingon, D.C.

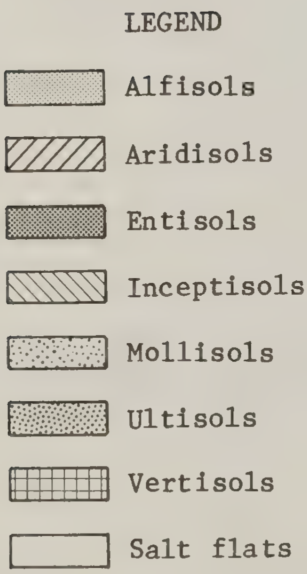
Figure 3-2--Rangeland as a percentage of total land area by State



Source: D.R. Satterlund, Wildland Watershed Management (John Wiley & Sons, 1972), p. 7.

Figure 3-3--Average precipitation in the western United States





Source: Buckman, H. O. and MN. C. Brady. 1969. The Nature and Properties of Soils. The MacMillian Company, Collier-MacMillian Limited, London.

Figure 3-4--Major soil orders of the western United States

when dry. Despite such limitations, these soils are widely tilled but yields from them are generally low.

The inceptisols lack accumulated clays, iron, and aluminum oxides--elements important for plant growth. They are generally agriculturally useful but may be limited by factors such as improper drainage. In the Pacific Northwest, these soils are quite fertile and provide the United States with some of its best wheat lands.

The aridisols are mineral soils that are dry throughout most of the year. They are generally low in organic matter and may have accumulations of soluble salts and calcium carbonate. Without irrigation, they are not suitable for growing cultivated crops. Some areas are used for sheep or goat grazing, but production per unit area is low. Where irrigation is available, aridisols can be very productive. Irrigated valleys in the western United States are among the most productive in the world.

The mollisols are thick and rich in organic matter. They have a high base saturation and do not become hard when dry. When first cleared for cultivation, their high native organic matter releases sufficient nitrogen and other nutrients to produce bumper crops even without fertilization. They are among the most productive cultivated soils in the world.

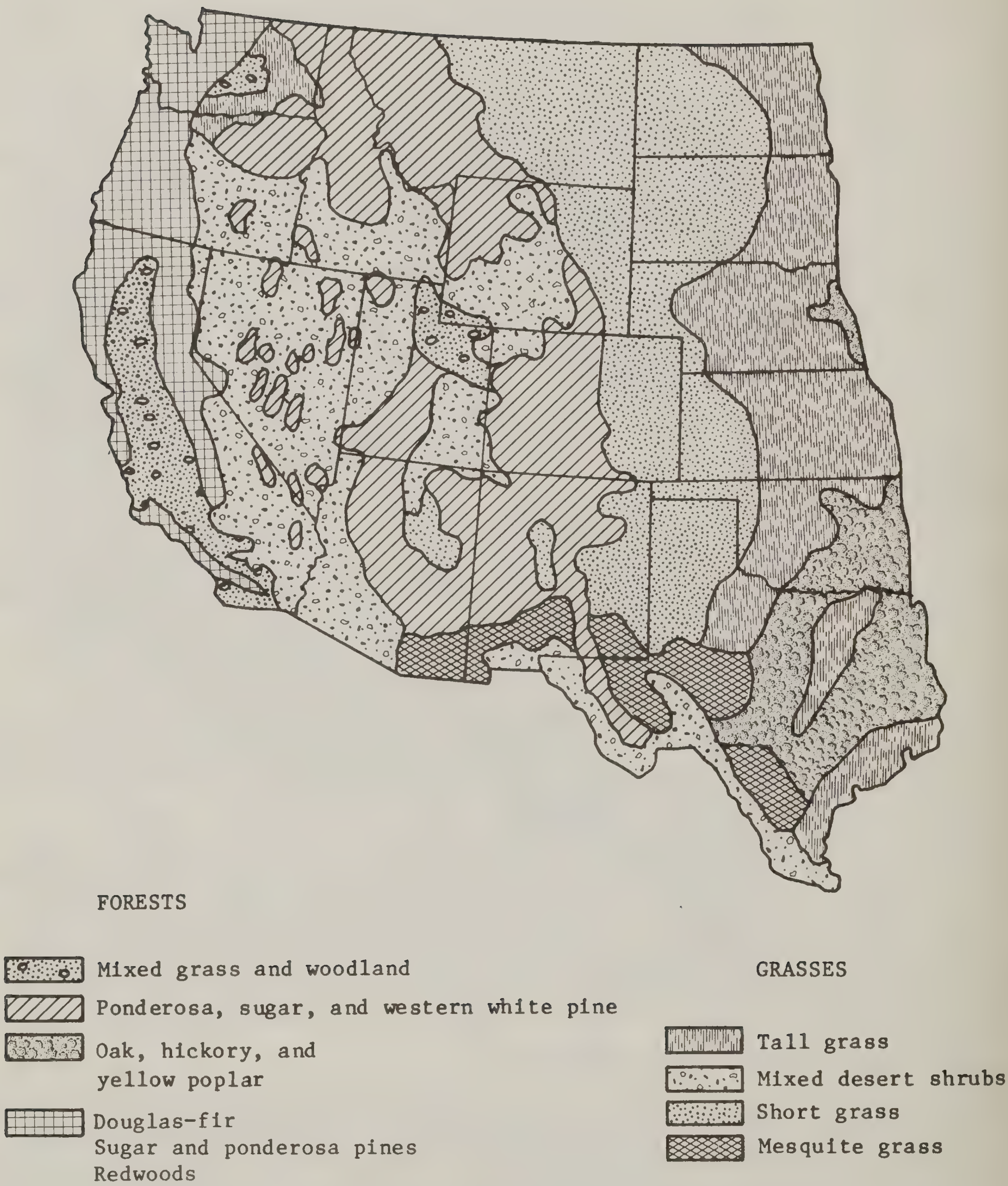
The alfisols have a medium to high base content (medium to high pH). The surface layers sometimes contain accumulations of silicate clay. The soils are quite productive, and their basicity usually favors good crop yields.

The ultisols are usually moist soils that develop in warm climates. Their surface layers are slightly acidic and have clay accumulations. They are not naturally as fertile as mollisols, but they respond well to good management. They are located mostly in regions of long growing seasons and ample moisture. With adequate fertilizers, these soils are quite productive and compete as excellent agricultural soils.

Rangeland Vegetation

Because the climate of much of the western States is semiarid or arid, the natural vegetation is predominantly grasses and shrubs (see figure 3-5). Tree growth is limited for the most part to mountain slopes and along rivers where moister conditions prevail. The vegetation of the remainder of the area is determined primarily by the amount and distribution of annual precipitation.

On the eastern portion of the range where annual precipitation is between 20 and 35 inches, tall and short grasses grow



Source: J.H. Paterson, North America: A Geography of Canada and the United States, Third Edition (Oxford University Press, 1965) p. 43, and O.S. Owen, Natural Resource Conservation: An Ecological Approach (The Macmillan Company, 1971), p. 234.

Figure 3-5--Major vegetation zones of the western United States

together, with species such as bluestem reaching heights above 6 feet. Here a deep soil humus layer has developed providing some of the most productive agricultural soils in the world.

The most extensive vegetation is the short grass area extending from central Texas and New Mexico to southern Canada. Common species here are the wheatgrasses, gramas, and buffalograss. The growth of vegetation, particularly root development, is restricted by the lower annual rainfall (12 to 20 inches). In the Southwestern States, the shortgrass type is replaced with a mixed grass-shrub community that includes gramas, dropseeds, and curly-mesquites and the mesquite shrubs and creosote bush.

The area between the Rockies and the Sierras, once supporting vegetation similar to the shortgrasses, is now predominantly sagebrush and shrubs because of past land use practices. The central basin of California supports annual grasses.

Topography, climate, and soils are the important factors that determine rangeland forage productivity. Rangelands with arid climates at high elevations or in northern latitudes tend to have lower forage productivity than lands more favorably situated. Rangeland productivity is measured by annual production of herbage and browse per acre. This amount varies from more than 2,700 pounds per acre in some of the fertile prairie areas to less than 300 pounds of herbage and browse in the arid desert regions. The number of animals a range area can support is determined by the amount of forage it can produce. Table 3-2 shows annual average herbage and browse production for the seven western analysis regions.

Wildlife

A wealth of animal life exists on the rangelands, with many species specially adapted to survive in the grassland environment. Burrowing or the use of burrows is a habit common to many mammals, such as prairie dogs, ground squirrels, the swift fox and ferrets, as well as snakes and even a bird, the burrowing owl. The burrowing habit is an adaptation to avoid predation, extreme weather, and fire. Running is another highly developed ability of rangeland wildlife. Birds like the roadrunner, Gambel's quail, and sage grouse, for example, rely on their running ability to escape predation (Brown, 1985).

Mammals typical of the rangelands include the coyote, striped skunk, and badger. The white-tailed deer, mule deer, pronghorn antelope, red fox, black-tailed and white-tailed jackrabbits, long-tailed weasel, and deer mouse are also common throughout much of the rangelands (Brown, 1985). Federally

Table 3-2--Total herbage and browse production and livestock production by analysis region

Production	Analysis regions						
	Tall-grass Prairie	Short-grass Prairie	Plateau	Desert	Great Basin	California Grasslands	Mountains
Herbage/browse production 1/	2,730	1,443	278	488	706	2,064	1,774
Total livestock production 2/	61,843	56,173	5,807	3,775	27,034	10,649	19,247

1/ In pounds per acre.
2/ In 1,000 AUM's (an animal unit month): the amount of forage required by a 1,000 pound cow or equivalent in 1 month.

Source: Adapted from Hewitt and Onsager (1983).

listed threatened and endangered species include the black-footed ferret, gray bat, Indiana bat, gray wolf, grizzly bear, and Utah prairie dog. (However, the gray bat and Indiana bat are not found in rangeland areas where control programs are likely.)

A wealth of avian fauna exists on the rangelands, and typical species include the turkey vulture; American kestrel; red-tailed, ferruginous, and Swainson's hawks; golden eagle; killdeer; mourning dove; barn owl; common nighthawk; horned lark; cliff, rough-winged, and barn swallows; loggerhead shrike; and red-winged and Brewer's blackbirds. The western meadowlark; lazuli and lark buntings; grasshopper, savannah, lark, Brewer's, chipping, and vesper sparrows; short-eared owl; western and eastern kingbirds; mountain and western bluebirds; black-chinned and broad-tailed hummingbirds; house finch; rufous-sided towhee; dark-eyed junco; common crow and raven; brown-headed cowbird; ring-necked pheasant; upland sandpiper; Say's phoebe; blackbilled magpie; rock and canyon wrens; American robin; and northern harrier also occur among the rangelands. The bald eagle, peregrine falcon, piping plover, least tern, and whooping crane are among the important federally endangered and threatened bird species found in rangeland regions.

Reptiles typical of most rangeland regions include the yellow-bellied racer, ringneck snake, western rattlesnake, pine-gopher snake, common garter snake, and horned lizard. Typical amphibians of the western rangelands include the western and plains spadefoot toads, Woodhouse's toad, great plains toad, and tiger salamander. These species prefer areas with dry loose soil to facilitate burrowing. The plains leopard frog and tree frogs are also found in the western rangelands, where they inhabit grassy moist areas along ponds, streams, and marshes (Brown, 1985). Federally endangered and threatened reptiles and amphibians of the rangeland include the desert tortoise and Wyoming toad.

Butterflies and moths found on the rangelands include the orange sulphur, common sulphur, woolly bear caterpillar moth, acraea moth, yellow woolly bear moth, sod webworm moth, cabbage white, common checkered skipper, artichoke plume moth, gray hairstreak, pipevine swallowtail, silvery blue, tiger swallowtail, monarch, painted lady, pearly crescentspot, and large wood nymph (Brown, 1985).

Other insects include the field cricket, green lacewing, green midge, yellow-faced bee, yellowjacket, American hover fly, toxomerus hover fly, paper wasp, digger wasp, large bee-fly, early tachinid fly, golden northern bumblebee, honey bee, tumblebug, three-lined potato beetle, and rose, pea, and potato aphid. Common spiders are the goldenrod spider, orb weaver,

jumping lynx spider, metaphid jumping spider, and the brown daddy-long-legs (Brown, 1985).

Water Resources and Aquatic Life

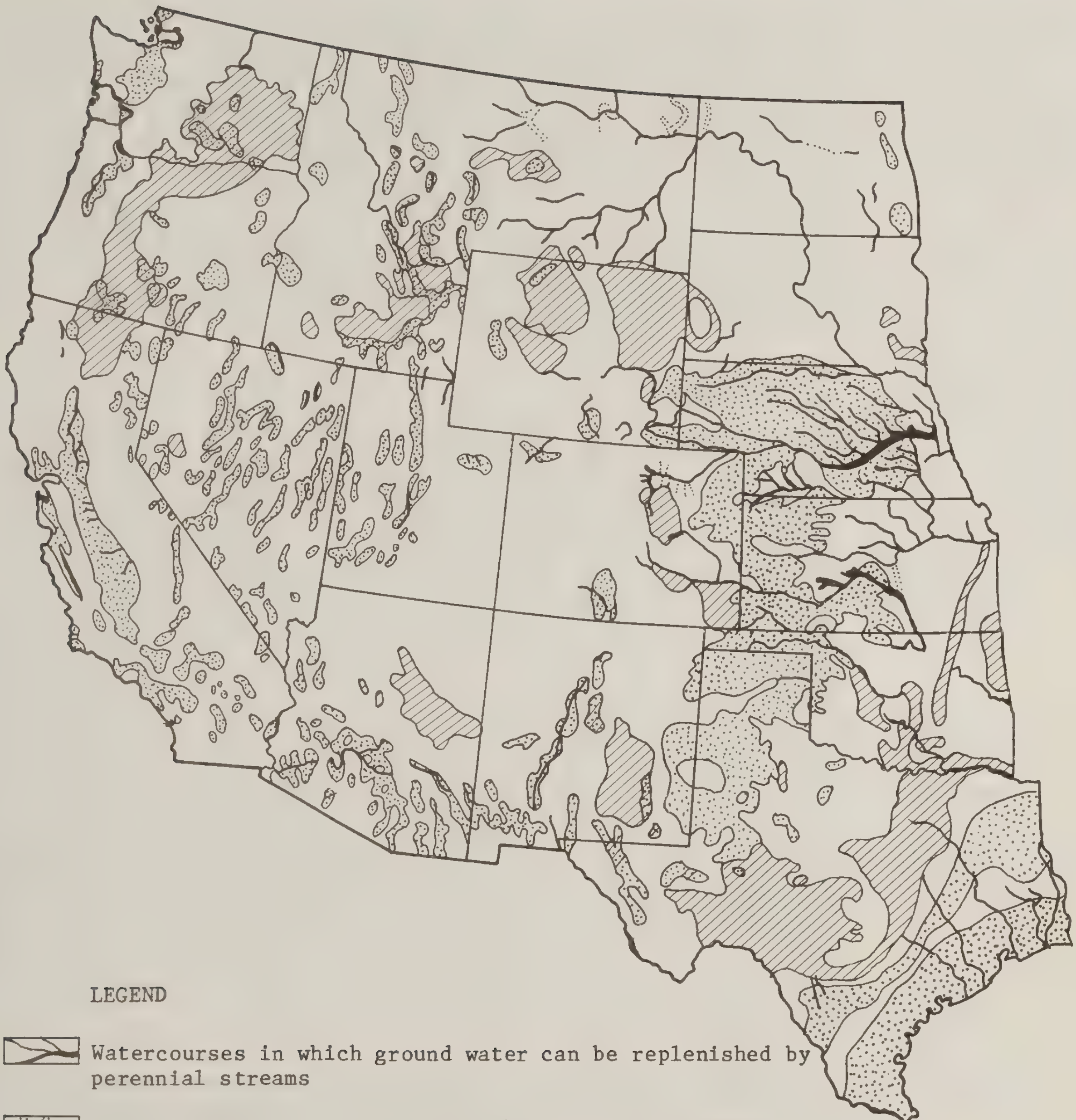
Water availability varies greatly in the western States, ranging from very abundant in the mountains to extremely scarce in the desert regions. The more mountainous areas are characterized by natural lakes and large, deep reservoirs. Ground water is abundant in the valleys and is used for irrigation and livestock watering. Water supply is low to moderate in the tall- and short-grass prairies. Surface lakes, shallow wells, and streams are used for irrigation and watering of animals. Intermittent waters such as prairie potholes are important breeding grounds as well as migration stops for waterfowl and other wetland species. The southwest and intermountain areas and the central California valley are characterized by low precipitation and unreliable water sources. Water for irrigation and livestock comes from the few reservoirs, large rivers, springs, and wells.

The ground-water resources of the rangelands are illustrated in figure 3-6. Aquifers in the region include outcropping, unconsolidated geologic units with unconfined water tables (including alluvial valley deposits), and confined aquifers (generally consolidated rock) overlain by relatively impermeable units. Confined aquifers receive little recharge from the surface because of the low permeability of overlying units and the lack of infiltration from precipitation. Unconfined aquifers may have water tables ranging in depth from 30 feet to more than 100 feet, as recharge from the surface is minimized by evapotranspiration and lack of precipitation. Water tables of unconfined aquifers approach and intersect the surface only along the channels of major permanent streams in the alluvial aquifers. Because of the operational requirement of a buffer 500 feet wide along any permanent water body, western aquifers are not likely to be at risk in areas where grasshopper control operations occur.

Rainbow and cutthroat trout are important game fishes in the mountain region of the West. Nongame species common to various analysis regions include the speckled dace, fathead minnow, and the red and redside shiners (Boschung et al., 1983). Endangered and threatened fish species of the rangeland include the bonytail chub, Colorado squawfish, greenback cutthroat trout, humpback chub, Lahontan cutthroat trout, woundfin minnow, and Kendall warm springs dace.

Human Populations

Except for the densely populated urban centers along the west coast and a few urban areas in the eastern section of the



LEGEND

Watercourses in which ground water can be replenished by perennial streams

Buried valleys not now occupied by perennial streams

Unconsolidated and semiconsolidated aquifers

Consolidated-rock aquifers

Both unconsolidated and consolidated-rock aquifers

Not known to be underlain by aquifers that will generally yield as much as 50 gpm to wells

Source: Tank, R.W., ed. 1976. Focus on Environmental Geology (2nd edition). Oxford University Press, Toronto, Ontario. 538pp.

Figure 3-6--Aquifers of the western United States

tall-grass prairie region, sparsely inhabited land constitutes the majority of the western United States. Most areas in the Great Basin, plateau, desert, and central mountain areas where grasshopper control is likely to occur have less than two persons per square mile. The short-grass prairie, California grasslands, and coastal and northern mountain regions are somewhat more densely populated (2 to 25 persons per square mile). The tall-grass prairie is even more densely populated, particularly in the central portion, where densities range from 60 to 125 persons per square mile (Rand McNally Atlas of the United States, 1983).

Air Quality

The Clean Air Act, as amended, divides the United States into Federal Air Quality Control Regions (AQCR's) on the basis of pollutant concentrations, geography, and economics. States are required to ensure that concentrations of designated pollutants do not exceed air quality standards for more than allowable periods. Standards have been set for six criteria pollutants--particulates, sulfur dioxide, nitrogen oxides, carbon monoxide, ozone, and lead--and for several hazardous pollutants. Most air pollution problems occur in industrialized and urban areas in the eastern States. The air quality of most of the western States has remained relatively pristine because of low population densities and lack of polluting industries. The major air quality problems that do occur in the west are confined to the urban areas of southern California and the smeltering industrial areas of southeast Arizona and southwestern New Mexico. Some undesirable conditions are also associated with powerplants in Utah and northern Arizona, agricultural activities and urbanization in central California, and burning related to forestry in the Pacific Northwest.

The Environmental Protection Agency also has identified special class I areas (national parks and wilderness areas) and vistas outside class I areas where visibility is an important value. The best visibility (more than 70 miles) exists in the mountainous Southwest, while the Pacific coastal regions have the poorest visibility (10 to 25 miles). The remainder of the 17 western States have very good visibility (ranging from 25 to 70 miles) (U.S. EPA, 1979).

Cultural and Visual Resources

The landscapes of the west possess a broad range of cultural and visual resources. Vast acreages are devoted to public lands, national parks and forests, and scenic vistas abound. The landscapes of the Rocky Mountains, High Sierras, Cascades, and Grand Canyon are among those areas valued for their scenic resources. Yellowstone in Wyoming, Yosemite in California,

and Big Bend in Texas are several of the larger national parks of high scenic quality and aesthetic appeal. Twenty-three designated wilderness areas totaling 368,739 acres and 860 wilderness study areas totaling 24,539,605 acres are protected and managed by the Bureau of Land Management. The national forests of the Pacific Northwest and other mountainous regions provide numerous and important resources for this Nation.

Historical and archeological sites are invaluable in understanding human cultural development in North America. The National Register of Historic Places, maintained by the Secretary of the Interior, is a basic inventory of the historical and archeological resources of the United States. The list includes more than 30,000 buildings, structures, objects, sites, districts, and archeological resources, many of which are located in the western States. Individual States also maintain a list of properties that are significant at the local or State level. In addition, Indian lands and places that are considered sacred are important cultural resources. Some of the more important resources are identified in the analysis region discussions in this chapter.

Land Uses

The land uses of the western rangelands include livestock grazing, agriculture, outdoor recreation, and natural resource use. Livestock grazing, primarily the grazing of beef cattle, is the major use of the range. Livestock grazing capacity for range acreage is commonly measured in animal unit months (AUM's), which is the amount of forage required by a 1,000-pound cow or equivalent in 1 month (USDA FS, 1981).

The USDA Forest Service uses the ecological status of rangelands and the resource value rating for livestock forage condition in analyzing rangelands. Livestock forage condition is determined by the species composition, production, and the adequacy of soil protection. Livestock forage condition is rated satisfactory or unsatisfactory depending on objectives established in the National Forest planning process and analyzed through range analysis. Generally, conditions in the 17 western States are poorest in the southern States and best in the northern States. Table 3-2 shows rangeland forage production and stocking levels in AUM's for each of the analysis regions.

Under the right conditions, land in the western States is used for the production of crops for human and livestock consumption. This is especially common along valleys of major streams and rivers where water allows for irrigated lands. Grains (such as wheat, oats, and barley), alfalfa, and hay are some of the principal crops, while fruits, vegetables, and other similar cash crops are also common.

Rivers and manmade reservoirs are commonly used for activities such as fishing, boating, swimming, and other recreational water sports. Public lands and national parks and forests are used for activities such as camping, hunting, hiking, skiing, and rock climbing.

The western States have many land areas that have been set aside for wildlife refuges and conservation areas, research natural areas, national natural landmarks, wild and scenic rivers, national historic landmarks, experimental forests and ranges, national trail systems, scenic areas, and Indian lands.

Many of the natural land resources of the west have been developed and used by man. The waters have been used for transporting fuel and raw materials and have been harnessed to provide inexpensive electricity. River systems have been used for the development of intensive irrigation systems to benefit water-poor lands, and the fisheries industry provides alternate food choices for man. Forests provide timber for construction, paper, and other wood products, while minerals have been obtained from natural deposits for uses such as building, making appliances, and manufacturing drugs.

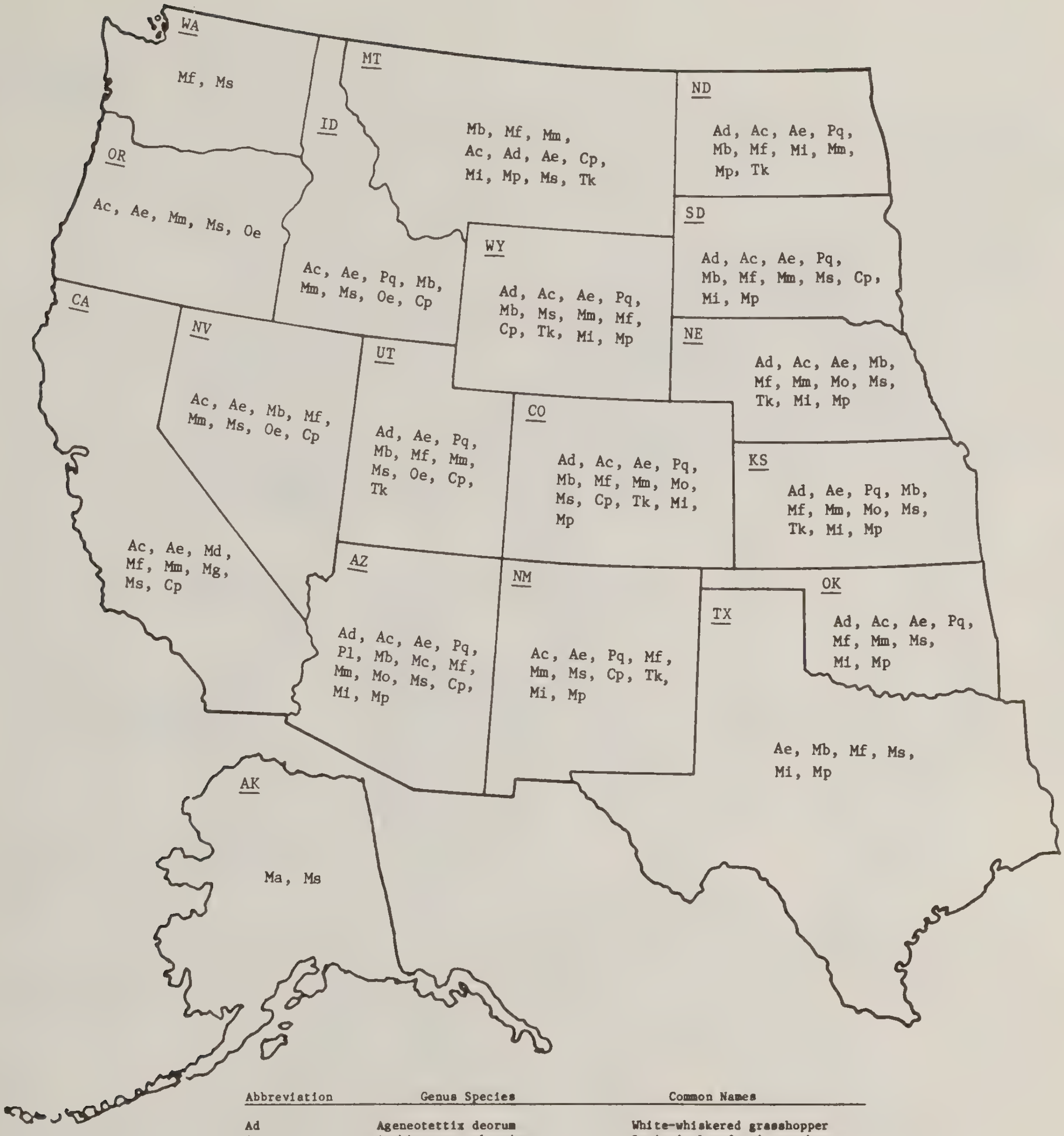
Grasshopper Distribution

A number of grasshopper species are considered economically important based on their damage potential. Some of those frequently found in the western United States are *Ageneotettix deorum*, *Aulocara elliotti*, *Phlibostroma quadrimaculatum*, *Melanoplus bivittatus*, *Melanoplus differentialis*, *Melanoplus femurrubrum*, *Melanoplus sanguinipes*, and *Camnula pellucida*. Figure 3-7 shows the economically important grasshopper species by State.

THE EIGHT RANGELAND ANALYSIS REGIONS

The eight analysis regions illustrated in figure 3-8 were derived from *Descriptions of the Ecoregions of the United States*, which classifies areas using similarities in ecology rather than a strictly geographical partitioning (Bailey, 1980). Uniformity of ecological setting was chosen as the most appropriate method for presenting the environmental information in this chapter. Where the effects of the APHIS grasshopper control program (discussed in chapter 4) differ among regions, those differences will be described in the context of these rangeland regions.

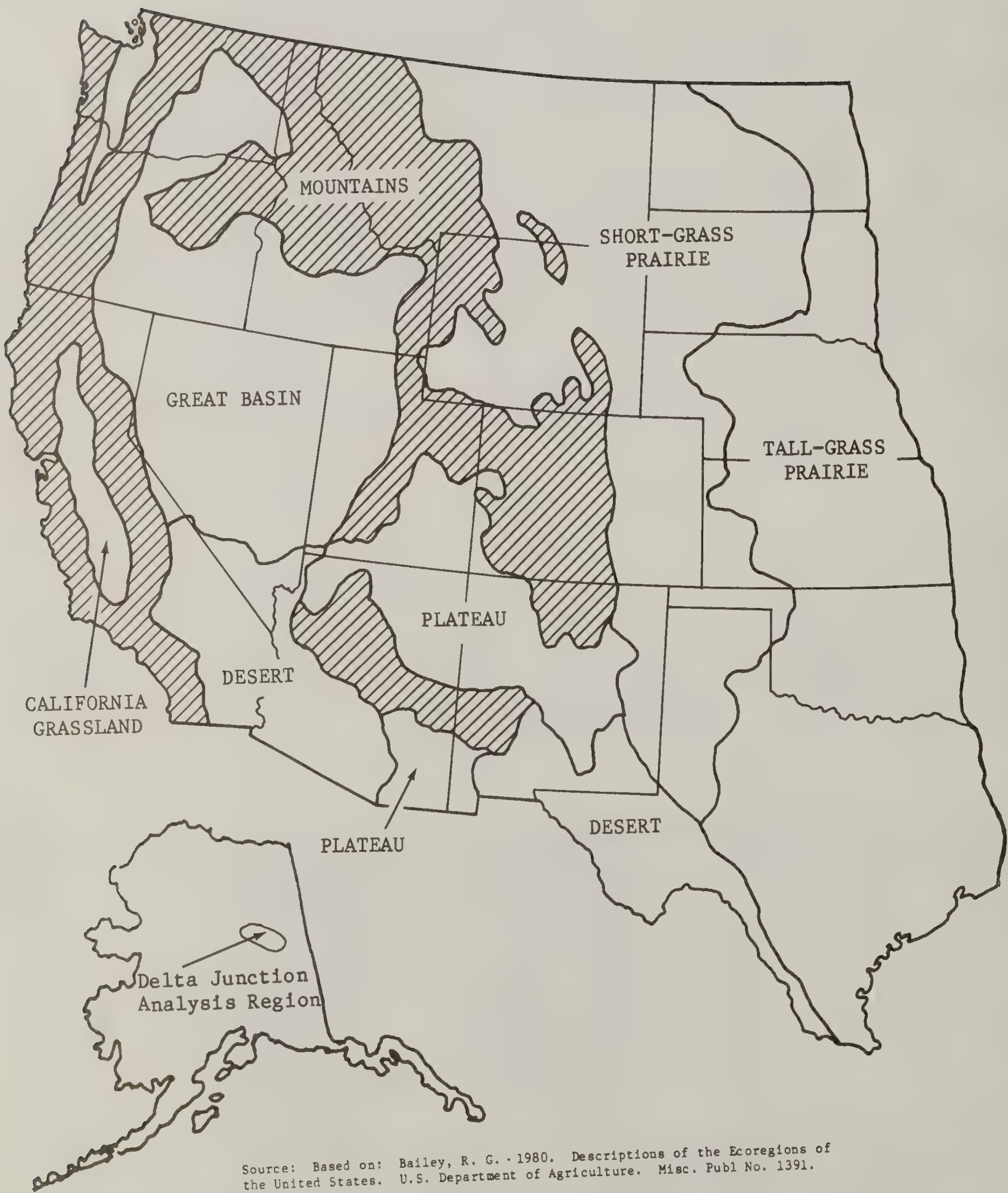
Endangered and threatened species and other wildlife common to many of the regions have been described in the overview section of this chapter. The following section describes elements and species that are unique to each region according to Bailey (1980), Brown (1985), and the U.S. Fish and Wildlife Service.



Abbreviation	Genus Species	Common Names
Ad	Ageneotettix deorum	White-whiskered grasshopper
Ac	Amphitornus coloradus	Striped slantfaced grasshopper
Ae	Aulocara elliotti	Bigheaded grasshopper
Pq	Philibostroma quadrimaculatum	No common name
Pl	Psoloessa delicatula	No common name
Mb	Melanoplus bivittatus	Twostriped grasshopper
Ma	Melanoplus borealis	No common name
Mc	Melanoplus cuneatus	No common name
Md	Melanoplus devastator	No common name
Mf	Melanoplus differentialis	Differential grasshopper
Mm	Melanoplus femurrubrum	Redlegged grasshopper
Mi	Melanoplus infantilis	Tiny spur-throated grasshopper
Mg	Melanoplus marginatus	No common name
Mo	Melanoplus occidentalis	No common name
Mp	Melanoplus packardii	Packard's grasshopper
Ms	Melanoplus sanguinipes	Migratory grasshopper
Oe	Oedaleonotus enigma	No common name
Cp	Camnula pellucida	Clearwinged grasshopper
Tk	Trachyrhachys kiowa	No common name

Source: USDA APHIS PPQ (undated) Grasshopper Survey: A Species Field Guide.
Hewitt, G.B. 1977. Review of Forage Losses Caused by Rangeland Grasshoppers. U.S. Department of Agriculture Miscellaneous Publication No. 1348.

Figure 3-7--Distribution of economically important grasshopper species by State in the western United States and Alaska



Source: Based on: Bailey, R. G. . 1980. Descriptions of the Ecoregions of the United States. U.S. Department of Agriculture. Misc. Publ No. 1391.

Figure 3-8--The eight analysis regions of the United States

Tall-Grass Prairie Analysis Region

Topography and Climate

The tall-grass prairie analysis region is a contiguous grassland of approximately 306,600 square miles that lies between the deciduous forests of the East and the short-grass prairie of the West, on the flat-to-rolling-hill land of the central lowland (see figure 3-8). Elevation gradually increases from about 500 feet above sea level in the east to about 1,500 feet in the West. The northern boundaries extend into Canada, and the southern boundaries extend through southeastern Texas. Most of the lands north of the Missouri River are young glacial drifts and dissected till plains. The area south of the Missouri River is older, has well-developed drainage systems, and is characterized by flat-to-rolling hills with plateaus occasionally dissected by canyons at the western end of the Gulf Coastal Plain.

The climate varies widely in this region. The length of the frost-free season varies from less than 120 days in the north to almost 300 days in the south. Annual precipitation ranges from 15 inches in the north to 30 inches in the south. In general, more precipitation occurs in the warmer months of the year. Drought periods are less frequent and less severe near the eastern forest than in more westerly areas. Annual average temperatures range from 40 °F in the north to 55 °F in the central portion to 70 °F in the south.

Soils

The soils of the prairie analysis region (see figure 3-4) are primarily mollisols, with black, friable, organic surface horizons and a high content of bases. Grass roots penetrate these soils deeply. Bases brought to the surface by plant growth are released on the surface and restored to the soil, perpetuating fertility. These soils are among the most productive of the soil groups. There are smaller areas of entisols, for example, in the mesquite-live oak savannah, and some vertisols. Most of the soils have dark upper horizons.

Vegetation

Most of the natural vegetation of the tall-grass prairie has given way to crop production; the dominant native vegetation is tall grasses associated with subdominant broad-leaved herbs. Trees and shrubs grow sparsely as woodland patches in valleys and other depressions. Bluestem grasses constitute the majority of the prairie vegetation and reach heights of 5 to 6 feet in lowland areas. Large numbers of flowering forbs exist but are usually overshadowed by the grasses. Most of the plants are classified as warm-season plants. Willow occurs in some places in exceptionally moist areas of the northern part of the region, and needle-leaved evergreens and broad-leaved deciduous

trees are scattered in the southern part. Some deciduous trees are found along permanent streams in the eastern portion. The southern plains are characterized by arid grasslands in which shrubs and low trees grow singly or in bunches. Mesquite grows in open stands among the grasses. Oak and juniper are often mixed with the grass and mesquite.

Terrestrial Wildlife

Bison once grazed at the western margin of the tall-grass prairie. Pronghorn antelope and coyotes are still present. Jackrabbits are numerous and cottontails live where there are streams and cover. Burrowing rodents include ground squirrels, prairie dogs, pocket gophers, and many smaller species. The plains pocket gopher and Franklin's ground squirrel are restricted entirely to the tall-grass prairie. Burrowing predators include the badger and the black-footed ferret, now considered an endangered species. White-tailed deer and wild turkey are abundant. The Mexican ground squirrel, fox squirrel, gray fox, and armadillo are present. Chief fur bearers are the ringtail, the raccoon, and the coyote.

The northern portion of the tall-grass prairie is an important breeding area for migrating waterfowl, many of which winter on the coastal plains of Texas. Mourning dove, scaled quail, sharp-tailed grouse, ring-necked pheasant, greater prairie chicken, and bobwhite are game birds present in fair numbers. The golden-cheeked warbler also occurs here. Attwater's prairie chicken, on the gulf coast of Texas, is listed as a federally endangered species. Shorebirds such as the killdeer, long-billed curlew, and upland sandpiper also occur here. The bald eagle, peregrine falcon, least tern, piping plover, eskimo curlew, and whooping crane are federally endangered or threatened species that inhabit this region.

Reptiles found in no other analysis region include the snapping turtle, prairie skink, racerunner, slender glass lizard, western ribbon snake, northern water snake, eastern hognose snake, prairie kingsnake, fox snake, and rat snake.

Common amphibians of this region include the Great Plains toad, Plains Spadefoot, Red-Spotted toad, Leopard frog, Great Plains narrowmouth frog, and the tiger salamander (Conant, 1958; Dickerson, 1969; and Brown, 1985). The Higgin's Eye pearly mussel is federally endangered in this region.

Many species of insects are found throughout the tall-grass prairie. Butterflies found exclusively in this region include the Dakota skipper, regal fritillary, and eyed brown. Other insects include the Nebraska conehead, red-blue checkered beetle, Pennsylvania and pyralis fireflies, robber flies, and the two-striped grasshopper.

Water Resources and Aquatic Life

Most surface waters in the tall-grass prairie region consist of reservoirs, farm ponds, and perennial and intermittent streams. Reservoirs provide flood control and water supply for municipalities and irrigation; farm ponds supply water for livestock and for irrigation. Shallow wells contribute water for most rural domestic uses and some livestock watering. Both deep and shallow wells are used for irrigation. Numerous prairie potholes provide breeding grounds for waterfowl and other wetland wildlife.

The most prevalent gamefish in this region are the largemouth bass, bluegill, channel catfish, smallmouth bass, and green sunfish. Abundant nongame species include common carp, creek chub, white sucker, gizzard shad, bluntnose minnow, central stone-roller, common shiner, fathead minnow, and golden shiner (Boschung et al., 1983).

Human Populations

Population densities range from less than 2 to 25 persons per square mile in the northern and southern areas of this region, to 25 to 60 persons per square mile from Kansas City to Houston in the central section. While a few urban areas in the eastern section of the tall-grass prairie region have high population densities, the majority of the rangeland areas are sparsely populated with a density of less than 2 persons per square mile. Thus, few humans should be at risk in any particular grasshopper control operation in this region.

Agricultural Land Uses and Cultural Resources

The gently rolling glacial topography and deep, fertile prairie soils of this region lend themselves to cultivation. Most of the area consists of farms and ranches with only a very small percentage of the land urbanized. Steeply sloping areas or shallow and sandy soils are used for rangeland. The northern area is heavily dry-farmed to spring wheat. Other spring grains, flax, and hay are also important. The central plains soil and climate favors production of winter wheat. Corn, alfalfa, grain sorghum, and cotton are grown under irrigation. In the southern portion, the land is increasingly devoted to the rangeland production of beef cattle. Cash crops in the southern portion include cotton, grain sorghum, wheat, feed grains, and hay.

Important cultural resources include several wildlife refuges in North Dakota, the Osage Indian lands in Oklahoma, and the Sisseton Indian Reservation in South Dakota.

Short-Grass Prairie Analysis Region

Topography and Climate

The short-grass prairie analysis region of 360,000 square miles lies in a broad belt that slopes gradually eastward from an altitude of 6,000 to 8,000 feet in the Wyoming Basin within the eastern Rocky Mountains to 1,500 feet in the Central States where it gives way to the tall-grass prairie. The mixed-grass prairie is included in the eastern portion of this analysis region and represents a transition zone between the tall-grass and short-grass prairies.

The short-grass prairie analysis region, characterized by rolling plains and table lands of moderate relief, includes the areas known as the Great Plains and Wyoming Basin. (See figure 3-8.) The most striking feature of the region is the phenomenal flatness of the interstream areas, which make up a great expansive flood plain or alluvial slope.

The climate is semiarid and the total supply of moisture is low. Precipitation ranges from 10 inches in the north to more than 25 inches in the south. Evaporation usually exceeds precipitation. Winters are cold and dry; summers are warm to hot. The frost-free season ranges from fewer than 100 days in the north to more than 200 days in parts of Texas. Average annual temperatures range from 40 °F to 60 °F.

Soils

Mollisols are typical of this region. The dominant soil-forming process is calcification; salinization is dominant in poorly drained sites. Soils contain a large excess of precipitated calcium carbonate and are rich in bases. Humus content is low because vegetation is sparse. The Wyoming basin has extensive alluvial deposits in stream flood plains and in fans at the foot of mountains. Dry lake beds are numerous, and there are extensive wind borne deposits, including both dune sand and loess.

Vegetation

Typical vegetation is steppe, which consists of numerous species of short grasses, bunched and sparsely distributed. Scattered trees and shrubs appear in the steppe. Sagebrush or shadscale is seen mixed with short grasses in the Wyoming basin. Because ground cover is sparse, much soil is exposed. Buffalograss is a typical grass; sunflower and locoweed are typical plants. The alkaline flats of the Wyoming Basin support alkali-tolerant species such as greasewood.

The mixed-grass prairie in the eastern section of this region is characterized by grasses of medium height, such as little bluestem, Junegrass, and needlegrasses. Tall and short

grasses as well as forbs and shrubs also grow here, creating a layered stand of open vegetation (Brown, 1985).

Terrestrial Wildlife

Large herds of buffalo once migrated with the seasons across the steppe plains. Now the pronghorn antelope is probably the most abundant large mammal, but mule deer and white-tailed deer are abundant where brush cover is available along stream courses. The white-tailed jackrabbit occupies the northern part of the area; the black-tailed jackrabbit occupies the southern part. Jackrabbits, prairie dogs, and several other small rodents are prey for the coyote and several other mammalian and avian predators. The black-footed ferret is classified as an endangered species.

Among the many smaller birds are Brewer's sparrow, McCown's longspur, and the golden-cheeked warbler, which is found in the southeast. The lesser prairie chicken, formerly abundant, occurs in fewer numbers here. Federally threatened and endangered species include the bald eagle, peregrine falcon, whooping crane, least tern, and piping plover. Construction of stock ponds has created an important duck habitat in the northern Great Plains.

Reptiles include the sagebrush lizard, great plains skink, and plains garter snake. The amphibians of the region are the same as those found in the tall-grass region. The Wyoming toad and the Higgin's Eye pearly mussel are federally endangered in this region.

Harvester ants found here have burrowing habits similar to the prairie dogs and often create their hills on prairie dog mounds. The dark zebra swallowtail exclusively inhabits this region and the prairie ringlet, alfalfa looper, Becker's white, and western tailed blue are other butterflies whose restricted range includes the short-grass prairie.

Water Resources and Aquatic Life

In the northern and eastern portions of this region, there are many kettle lakes and prairie potholes that are important to wildlife. In southern sections, there are numerous playa lakes; most of these are ephemeral, although some are moist year round. The relatively few perennial streams are typically broad, sluggish, and silt-laden. Many ponds and small reservoirs have been constructed on intermittent streams, and large reservoirs have been constructed on larger rivers. Extensive systems of irrigation ditches have increased aquatic habitat.

Throughout the region, suspended sediment is a water quality problem; increased salinity is also a problem in southern sections.

In most shallow waters with adequate nutrients, a rich invertebrate fauna exists. However, few fish are found here except in ponds and reservoirs where warm-water species have been introduced. The most common gamefish include bluegill, channel catfish, green sunfish, yellow perch, and walleye. Nongame fish include the gizzard shad and central stone roller (Boschung et al., 1983).

Human Populations

With the exception of a few urban areas, this analysis region is characterized by low population densities. Rural areas have moderate densities ranging from 2 to 25 persons per square mile. However, the rangelands that dominate this analysis region are sparsely inhabited with population densities less than 2 persons per square mile. Populations at risk in grasshopper treatment areas in the rangelands of this region should be very low.

Agricultural Land Uses and Cultural Resources

The short-grass prairie region is considerably more arid than the tall-grass region to the east. Progressing west and south within this region, livestock grazing on native as well as improved rangeland becomes increasingly important. To the east and where sufficient moisture exists for agriculture, the principal crops are wheat, grain sorghum, sugarbeets, soybeans, corn, and other feed grains. Cotton is also grown in irrigated areas in the southern part of the region.

The Little Missouri National Grassland in North Dakota is one of the short-grass region's valuable resources. The Black Hills National Forest and several tracts of Indian lands, including the large holdings of the Cheyenne Indians, are also important cultural resources.

Plateau Analysis Region

Topography and Climate

The plateau analysis region of 94,700 square miles includes two separate (noncontiguous) geographical areas: the Colorado Plateau in Arizona, New Mexico, and Utah, and the Mexican Highlands located between the American Desert on the west and the Chihuahuan Desert on the east (see figure 3-8). The topography covers high, grassy mountains of the Mexican plains as well as the table lands and mountains of the Colorado Plateau. Local relief is from 500 feet to more than 3,000 feet in some of the deeper canyons that dissect these table lands, and

volcanic mountains rise 1,000 to 3,000 feet above the plateau surfaces. Stream valleys are narrow and widely spaced.

The high elevations of this region produce moderate mean temperatures. However, summer days are hot and extremely cold weather occurs in winter. The annual average temperatures range from 40 °F to 55 °F in the plateau region and from 55 °F to 70 °F on the Mexican plains. Normal rainfall occurs in winter; summer rains occur as occasional, sudden thunderstorms. Average annual precipitation ranges from 10 to 20 inches on the Colorado Plateau. The Mexican Highlands are semiarid and have less rainfall.

Soils

The dominant soil type of the plateau region is the aridisol. It can be found in all basins and lowland areas as well as in the deserts and plains. It is low in organic matter and generally is not suitable for crops. Some entisols are found in narrow bands in stream flood plains of the Colorado Plateau.

Vegetation

Vegetational zones are varied in the plateau region. The lower elevations are arid grasslands (shortgrass) with many bare areas and a variety of cacti. Sagebrush, mesquite, yucca, and other shrubs are also present. The submontane belt includes several species of oak and juniper and some pinyon pine. The montane zone is dominated by pines and fir.

Terrestrial Wildlife

Typical mammals include the mule deer, mountain lion, coyote, and bobcat. Smaller species include the kangaroo rat, cliff chipmunk, and rock squirrel. Small rodents are preyed on by golden eagles, great horned owls, and the ferruginous, red-tailed, and Swainson's hawks. Endangered or threatened wildlife in the plateau include the black-footed ferret, Utah prairie dog, bald eagle, peregrine falcon, and whooping crane.

The most abundant birds are the plain titmouse, Woodhouse's jay, red-shafted flicker, pinyon jay, lead-colored bushtit, and rock wren.

Reptiles include the Gila monster, the lesser earless and collared lizards, the western terrestrial garter snake, and the pine gopher snake.

Insects of the plateau region include the rough harvester ant and butterflies, such as the sleepy orange, small-checkered skipper, various blues, and the mylitta crescentspot.

Water Resources and Aquatic Life

Water is scarce throughout the area. Low precipitation and intermittent streamflow provide a small amount of water for agriculture. A few reservoirs and wells add to the water resources. Ground water is scarce and in some areas has been noticeably decreasing in the past several years. Water from Navajo Lake in northern New Mexico is to be used for an irrigation project planned for the San Juan River Valley region. Other major waters lying within this region include Lake Powell, San Carlos Lake, and the Colorado and Gila rivers.

The speckled dace is a common fish species in the plateau region (Boschung et al., 1983). Federally endangered and threatened fish species include the Colorado squawfish, humpback chub, bonytail chub, woundfin, and Gila topminnow.

Human Populations

Perhaps because of the irregularity of its terrain and water supply, this analysis region is very sparsely populated. The majority of its areas have less than 2 persons per square mile. The population at risk from any grasshopper control operation in this region is likely to be very low.

Agricultural Land Uses and Cultural Resources

Most of the plateau region is used for grazing sheep and cattle. Much of the grazing land is federally owned. Irrigated croplands are found along the valleys of major streams. Alfalfa, grain, corn, and hay for livestock feed are the main crops, but fruits, vegetables and other cash crops are also grown. Land-use problems resulting from declining water tables and short supply of irrigation water are common. Overgrazing contributes to the invasion of brushy vegetative species and gully erosion.

The White Sands missile range in New Mexico and the large Navajo Indian Reservation in Arizona are located in this region. Olympic and Glacier National Parks and the Chiricahua National Monument are important resources of the region.

Desert Analysis Region

Topography and Climate

South of the Rocky Mountains are the extremely arid continental deserts. This analysis region (141,600 square miles) includes the Chihuahuan Desert in southern New Mexico and western Texas and the American Desert in California, Arizona, Nevada, and Utah (figure 3-8). The topography is characterized by extensive plains from which isolated mountains and buttes rise abruptly. Elevations range from 280 feet below sea level to 11,000 feet above sea level in some mountain

ranges. The only permanent streams are a few large rivers that include the Colorado, Rio Grande, and Pecos Rivers. Washes, dry most of the year, fill with water following a rain.

Summers are long and high temperatures prevail. Though winters are moderate, the region is subject to occasional frosts and freezing temperatures. Average annual temperatures range from 50 °F to 75 °F. Summer rains occur as torrential storms; in winter, the rains are more gentle and widespread. In the Colorado and Mojave Deserts of southeastern California, there are virtually no summer rains. Average annual precipitation ranges from 2 to 10 inches. The evaporation rate in summer is very high.

Soils

The soils of the desert region are primarily aridisols. These are found in drier climates and tend to remain dry throughout most of the year. They are low in organic matter but may support vegetation suitable for livestock grazing. Entisols may occur on some of the older alluvial fans and terraces, as well as in the better drained basins of the desert region.

Vegetation

Vegetation is sparse and consists of cacti and thorny shrubs. Short grass grows in association with the shrubs in some places. Creosote bush and mesquite are widespread. Juniper and pinyons are limited to the higher areas. The desert mountains are exceptionally barren, and many are almost devoid of vegetation.

Terrestrial Wildlife

Mammals of the region include the desert kit fox, collared peccary, and western spotted skunk. The black-tailed jackrabbit, desert cottontail, wood rat, kangaroo rat, and numerous smaller rodents compete with domestic and wild herbivores, such as the desert bighorn, for available forage and are preyed on by the coyote, bobcat, golden eagle, burrowing owl, red-tailed hawk, and ferruginous hawk. Areas where tall cacti are plentiful provide homes for many birds, including the Gila woodpecker, cactus wren, and verdin. The federally endangered Sonoran pronghorn inhabits this area, although few of these animals are left in southern Arizona. The masked bobwhite quail is a federally endangered species here.

Reptiles include the Texas horned lizard, western whiptail lizard, and side-blotched lizard and numerous snake species, including the western diamondback rattlesnake, the long-nosed snake, and the Texas blind snake.

Butterflies such as the west coast lady, mylitta crescentspot, and various blues inhabit the desert grasslands. Arthropods such as the scorpion and tarantula also inhabit this region.

Water Resources and Aquatic Life

Because annual precipitation in this region is less than 8 inches (some desert areas average less than 4 inches), water is scarce. Irrigation water for agriculture comes mostly from the Colorado and Mojave Rivers. Some irrigation water is obtained from large springs in Nevada and local wells in various areas. The Rio Grande and Pecos Rivers are the only perennial streams that provide water in the southern desertic basins. These water sources are also used to supply livestock with drinking water year round. The fisheries of Lakes Mead, Mohave, and Havasu, the reservoirs of interior Arizona, and the Colorado, Salt, Verde, and Gila rivers provide a large amount of sport fishing recreation in this region.

Important native fish species in the desert region include the desert pupfish, longfin dace, and roundtail chub (Boschung et al., 1983). Federally endangered and threatened fish species include the woundfin, bonytail chub, and Gila topminnow.

Human Populations

Populations in the desert region vary greatly. While urban and suburban parts of southeastern California and southwestern Arizona have moderate population densities, the rangelands of the desert region are very sparsely populated. Most of these arid, hot rangelands have less than 2 persons per square mile. Grasshopper treatment programs are unlikely to affect human populations in this region's rangelands.

Agricultural Land Uses and Cultural Resources

With the exception of the Imperial Valley, approximately 75 percent of this region is owned by Federal and local governments. The remainder is in private ownership and consists of mostly farms and ranches. Grazing is limited because of poor forage production and lack of water. Intensive irrigated agriculture is practiced in the Imperial Valley. Citrus fruit, dates, grapes, sugarbeets, many kinds of vegetables, small grains, hay, and tame pasture grasses are grown. Livestock are fattened each year in feedlots.

Important public resources include the Lake Mead National Recreation Area, Death Valley National Monument in California, and Big Bend National Park in western Texas. A 191-mile stretch of the Rio Grande River along the Mexican border has been proposed for inclusion in the Wild and Scenic Rivers System.

Great Basin Analysis Region

Topography and Climate

The Great Basin analysis region of 215,800 square miles occupies the area between the Rocky Mountains on the east and the Sierra Nevada Range on the west, its elevation varying from mountainous regions to low elevations along the Snake River Plain. This includes areas in Nevada, Utah, southern Idaho, Washington, and Oregon (figure 3-8). Much of this intermountain area is numerous separate interior basins, and only a small portion of it drains to the sea. Except for the Snake River and its tributaries in the Snake River Plain, streams in this region are generally intermittent. Many mountains rise steeply from the semiarid, sagebrush-covered plains.

Summers are hot; winters are fairly moderate. The average annual temperature is 40 °F to 55 °F. Spring comes early except at the higher elevations. Total annual precipitation averages only 5 to 20 inches; almost no rain falls during the summer months except in the mountains.

Soils

Aridisols dominate the basin and lowland areas and are dry throughout most of the year; mollisols are found at higher elevations and are rich in organic matter. Basicity of mollisols is high and the soils remain soft when dry. Narrow bands of entisols lie in stream flood plains. Salt flats, as well as playas without soils, are extensive in the lower parts of the basins that have interior drainage.

Vegetation

Sagebrush dominates the vegetation of the lower elevations. Other common plants include shadscale, fourwing saltbush, rubber rabbitbrush, spiny hopsage, and horsebrush. Most of the shrubs tolerate alkali in varying degrees.

In the montane belt, ponderosa pine dominates the lower and more exposed slopes; Douglas-fir, the higher and more sheltered ones. Fir and spruce are found in the smaller subalpine belt.

Terrestrial Wildlife

Antelope, bighorn sheep, elk, black bear, mule deer, mountain lion, bobcat, and badger are some of the larger mammals in this region. The most common species are small mammals such as ground squirrels, jackrabbits, kangaroo mice, wood rats, coyote, and kit fox. Common birds include the lazuli bunting, Tolmie warbler, meadowlark, and little flycatcher. The short-eared owl and marsh hawk are common predatory birds. The sage grouse also occurs here, although in few numbers in

Washington and Oregon. Endangered or threatened species include the black-footed ferret, grizzly bear, gray wolf, woodland caribou, bald eagle, peregrine falcon, and whooping crane.

Common reptiles of the Great Basin include the common garter snake and western rattlesnake. Typical insects include butterflies such as the skippers, blues, the west coast lady, and Riding's satyr, as well as various flies, bees, and beetles. Federally threatened arthropods include the Oregon silverspot butterfly and Ash meadows naucorid.

Water Resources and Aquatic Life

The low precipitation in much of this region provides generally small and unreliable sources of water. The water sources of the Snake River support more than 50 percent of the population of Idaho and the Great Basin area. It is very important for the irrigation of lands that support agricultural crops and grazing animals.

Ground water is plentiful in the Snake River area and is used extensively for irrigation (USDA SCS, 1981). Small reservoirs supply additional water for irrigation and recreation; a few terminal lakes are used mainly for recreation. Elsewhere in this region, ground-water supplies are limited and largely untapped. Shallow wells commonly contain large amounts of salt.

The many unique aquatic habitats in this region contain a variety of flora and fauna. Among the more unusual habitats are thermal springs, extremely saline waters, lava collapse ponds, ephemeral ponds, and caldera lakes. Saline waters in southern sections support dense populations of phytoplankton and zooplankton. In reservoirs in the north, warm-water fish species have been introduced and often coexist with cold-water species of trout and salmon.

The cutthroat trout, brown trout, least chub, and speckled dace are important fish species in the Great Basin (Boschung et al., 1983). The June sucker and Lahontan cutthroat trout are federally endangered and threatened species found here. The most abundant amphibians of the Great Basin region are the common leopard frog and the western frog (Dickerson, 1969).

Human Populations

Except for a few areas of dense populations in urban areas of Utah and Nevada, the Great Basin region has low densities of human inhabitants. The rangelands of this region are very sparsely populated with less than 2 persons per square mile. It appears unlikely that the few inhabitants of the rangelands

in this region would be affected by grasshopper treatment programs.

Agricultural Land Uses and Cultural Resources

A large portion of the land is federally owned and the remainder is farms and ranches. More than 90 percent of all land in this region is rangeland (USDA SCS, 1981). Irrigation is practiced where water is available and soils are suitable. The Snake River and its tributaries irrigate more than 25 percent of this region, supporting some of the most agriculturally productive lands in the western United States. Small acreages are used to grow feed crops and some wheat. Peas, beans, and sugarbeets also are grown.

The primary agricultural activity on the vast rangelands in this region is livestock production. In the Snake River Plain, opportunities exist to increase forage production with improved management and condition (USDA, 1984). Open forests on high mountain slopes also provide important habitats for wildlife and livestock grazing.

Large tracts of land in this region are used for training and testing purposes by the Armed Forces and the Nuclear Regulatory Commission. Land-use problems include proper use of rangelands, efficient use of water supplies, and control of erosion in critical areas.

Part of the lower Snake River has been designated as a Wild and Scenic River, whereas part of the middle Snake River in southern Idaho includes the Bureau of Land Management's Birds of Prey Area where the largest known nesting population of prairie falcons exists. The Desert National Wildlife Refuge and several antelope ranges in Oregon and Nevada are prized resources in the Great Basin region. Large tracts of National Forest land are located in western Oregon, and Humbolt National Forest is an important resource in Nevada. Eighty-seven percent of Nevada is public land managed by the Bureau of Land Management. Smaller tracts of American Indian lands run throughout the area.

California Grassland Analysis Region

Topography and Climate

The California grassland analysis region lies within the Central Valley of California, a flat alluvial plain of 20,200 square miles between the Sierra Nevada and the coast ranges (figure 3-8). Elevations range from sea level to 500 feet. This area has broad, nearly level valleys bordered by sloping alluvial fans, slightly dissected terraces, and the lower foothills of the surrounding uplands. Large undrained basins are in the south.

The precipitation of this climate is characterized by winter rainfall. Except near the coast, summers are hot and the winters mild. Annual rainfall ranges from 6 inches in the upper San Joaquin Valley to nearly 30 inches along the coast. Potential evaporation during the warmest months is often much greater than the precipitation. Annual temperatures average 60 °F to 67 °F in much of the area. Northern temperatures fall as low as 55 °F.

Soils

The majority of soils of this region are entisols and alfisols. The entisols are usually found at the lower elevations and lack significant soil layers. The alfisols at slightly higher elevations have a medium to high pH. A small area of aridisols occurs in the more arid southern portions of the San Joaquin Valley where water supply is limited and the soil is dry most of the year.

Vegetation

The Central Valley of California was once dominated by natural grasses, similar in appearance to mixed prairie, which plowing, fire, and grazing have eliminated. The vegetation today consists of various species of introduced annual grasses (avens, brome, fescue) and barley.

Rivers flow through alkaline flats where greasewood, picklewood, salt grass, and shadscale are the primary cover. Tule marshes border the lower reaches of the San Joaquin and Sacramento Rivers.

Terrestrial Wildlife

Intensive agricultural development has changed the fauna of the annual grasslands. As a result, larger species, such as the California grizzly, gray wolf, elk, and pronghorn antelope, have been eliminated or have moved to the hills. The San Joaquin kit fox is classified as a federally endangered species. Common mammals include the Beechy ground squirrel, cottontail, black-tailed jackrabbit, pocket mouse, and kangaroo rat. Coyote and bobcat live in the adjacent woodlands.

Common birds are the Brewer's blackbird, loggerhead shrike, and scrub jay. The roadrunner, which feeds on reptiles and insects, is also common to this area. California quail are numerous in the brushy areas. The yellow-billed magpie is found only in this region. Avian predators include the golden eagle, desert sparrow hawk, and Cooper's hawk. The California condor, a federally endangered species, also occurs here.

Reptiles include the western skink, bluntnose leopard lizard, western whiptail, pine-gopher snake, coachwhip, and western rattlesnake. The western spadefoot is the most common amphibian in the California grasslands (Brown, 1985).

Among the various insects are the ornate tiger moth, Becker's white, west coast copper, and various blue butterflies. The Palos Verdes blue butterfly and Smith's blue butterfly are federally endangered in this region, while the Delta green ground beetle is federally threatened.

Water Resources and Aquatic Life

Because of the low rainfall and relatively small stream flow, water is scarce in many parts of the California grasslands region. Water for irrigated crops and livestock watering comes from stream diversions, wells, and canals of organized irrigation districts. These obtain most of their water from State and Federal water systems.

In this ecoregion, the most important fish include the Sacramento perch, hitch, splittail, California roach, Sacramento squawfish, and the speckled dace (Boschung et al., 1983).

Human Populations

Most of the California grassland region is moderately populated. Densities range from 25 to 60 persons per square mile. In contrast, the rangeland areas of this region are generally only sparsely inhabited, having a population density of less than 2 persons per square mile. Thus, the potential population at risk in any APHIS grasshopper control would likely be very small.

Agricultural Land Uses and Cultural Resources

More than 90 percent of this region is farms and ranches. Much of the remainder is federally owned. About 2 or 3 percent is urban, and the acreage used for this purpose is increasing rapidly. Slightly more than half the area is cropland, three-fourths or more of which is irrigated. Cotton, fruits, nuts, grapes, hay, grain, pasture, rice, alfalfa, citrus, and tomatoes are among the principal crops grown on irrigated land. The more sloping, nonirrigated cropland is dry-farmed to grain. About a third of the area is in native grasses, brush, and open woodland and is used mostly for grazing. Wind erosion is a problem in many areas if a plant cover is not maintained.

Mountain Analysis Region

Topography and Climate

The mountain analysis region (452,100 square miles) encompasses the wide variety of mountainous areas in the western United States. The Pacific and Sierra Forests and California chaparral extend down the west coast while the Rocky Mountains, Columbian Forest, and Upper Gila Mountains dissect the central region (figure 3-8). The mountain environments are characterized by high, steep, rugged slopes. Many areas are glaciated; others are volcanic. Plateaus of dissected, horizontally layered rocks are found in the Rocky Mountains and Upper Gila Mountains.

The climates vary considerably with altitude. Temperature decreases and precipitation increases with rising elevations. Winter produces the most precipitation and much of it falls in the mountains as snow. Average rainfall ranges from 10 inches in the semiarid Rockies to 150 inches in the humid Pacific Northwest.

Overall, temperatures are moderate, although severe winters are characteristic of the northernmost regions. Average temperatures range from 35 °F to 55 °F in most areas. The southern coastal region is somewhat warmer.

Soils

Soil orders are varied. Mollisols and alfisols are found in montane zones and along the California chaparral coast. Aridisols occur in the foothill zones. Inceptisols are found in the cool, moist areas of the Columbia forest and in areas of the Rocky Mountains where recent glaciation has occurred. Ultisols occur in the Pacific and Sierra forests where the air is humid. At lower elevations, entisols occupy the flood plains and alluvial fans of the valleys. The Colorado River Valley is mostly entisols.

Vegetation

Vegetation in the western mountains varies widely depending on altitude, latitude, prevailing winds, and slope exposure. Many areas show well-marked zones. Douglas-fir, pines, hemlock, and cedar are found in most montane belts. However, montane vegetation in the California chaparral is dominated by sclerophyll shrub species having thick, hard evergreen leaves. Subalpine areas favor spruce and fir. The Pacific region is extremely dense and is famous for its huge redwoods. A few groves of giant sequoia grow on the western slopes of the Sierras. At lower elevations, shrublands, grasslands, and chaparral prevail.

Terrestrial Wildlife

Large mammals common to most of the mountain region include the black bear, elk, and the mountain lion. Grizzly bear and moose are found in northern regions of the Rockies. Small populations of bighorn sheep are found throughout the Rockies. Smaller mammals include tree and ground squirrels, martens, and chipmunks. Familiar bird species include chickadees, juncos, and nuthatches. Mountain quail, chukar partridge, and wild turkey are common game birds. Endangered and threatened wildlife species of the mountain region include the California condor, whooping crane, bald eagle, peregrine falcon, black-footed ferret, grizzly bear, gray wolf, woodland caribou, and Utah prairie dog.

Mountain reptiles include the western hognose snake, bull-snake, and prairie and western rattlesnakes. The most common amphibians of this region include the Rocky Mountain toad and common leopard frog of the Rocky Mountain States and the Pacific tree frog and *Rana aurora* of the Sierras and Pacific coast (Dickerson, 1969).

Common insects in this region are various species of blues, coppers, and nymph butterflies. The Palos Verdes blue butterfly and Smith's blue butterfly are federally endangered. The Oregon Silverspot butterfly, narrow foot hygrotis water beetle, and the Delta green ground beetle are federally threatened arthropods.

Water Resources and Aquatic Life

In the central and northern sections of this region, water is abundant. Many headwater streams originate in the mountains. Natural lakes are common, and numerous large and deep reservoirs have been constructed on major rivers to provide water for irrigation, power, and domestic and municipal uses. Most natural lakes and ponds are relatively shallow and are rich in organic matter. Reservoirs are typically much deeper and colder and are relatively nutrient-poor. Ground water, relatively abundant in many valleys, is used for irrigation and livestock watering. In ridges and in intermountain basins, ground water is usually scarce. Water quality in the region is generally good, although salinity is a problem in the lower reaches of many major streams.

In southern sections of this region, and at lower elevations, there are more moderate supplies of water. Ground-water supplies are limited.

The fish fauna in the region is relatively sparse. At high elevations, trout and suckers may be the only species present. Cutthroat trout is one of the few native trout species,

although the rainbow trout, which was introduced to the region, is now dominant. The brook and brown trout, also introduced to this region, are important as well. The federally threatened and endangered Arizona and Gila trouts inhabit small areas of the mountain region. Of particular interest in the northwest sections of this region are the spawning runs of various species of Pacific salmon. While they have decreased in some rivers, runs are still substantial in many rivers.

In the mountains ecoregion, the rainbow trout, brook trout, and cutthroat trout are the major gamefish and provide much recreational value to the area. Common nongame fish found in the more northern mountain area include the longnose dace and the white sucker (Boschung et al., 1983).

In Washington and Oregon, the coho salmon, sockeye salmon, chinook salmon and steelhead trout are important as sportfish and in commercial fisheries. These species are anadromous; that is, the adults spawn in freshwater and the young migrate to the ocean (Boschung et al., 1983).

Human Populations

The mountain analysis region varies considerably in population density. Most of the central and southern areas of the region are very sparsely populated (less than 2 persons per square mile). The northern sections in Washington and Idaho are somewhat more densely settled, while the heaviest human concentrations occur along the west coast in the major urban centers of Seattle, Portland, San Francisco, Los Angeles, and San Diego. The rangelands of this region provide a sharp contrast to the major urban centers of the region. Here the population densities are very low, numbering less than 2 persons per square mile; the population likely to be at risk in a particular grasshopper control operation therefore would be very small.

Land Uses and Cultural Resources

A large percentage of the mountain region is federally owned; the remainder is farms, ranches, and other privately owned land. Lumber is a major industry, and large tracts of land in the Rockies are controlled by large commercial timber companies. Forests and woodland areas provide important wildlife habitats and grazing for livestock. Mining occurs in Idaho, western Montana, and the Cascade Mountains. Cropland accounts for only a small portion of the acreages in this vast region. Erosion and fire are problems in the mountain regions.

The mountainous regions of the west provide vast areas of national parks and forests including those situated in the

Rocky Mountains, Sierras, and Cascades. Yosemite and Yellowstone National Parks are two of the best known. Coconino National Forest in Arizona and Gila National Forest in New Mexico are additional major resources. Northern areas of the region are rich with Wild and Scenic Rivers including the Snake, Salmon, Flathead, and Missouri Rivers.

Delta Junction Analysis Region

Topography and Climate

The Delta Junction analysis region of Alaska covers approximately 150 square miles (110,000 acres) of rangeland. It is located along the Tanana River and extends for approximately 100 miles east of Delta Junction, Alaska (figure 3-8). The Delta Junction analysis region lies between mountainous stretches of coniferous forests in the intermontane plateaus of Alaska and constitutes the eastern section of the Tanana-Kuskokwin lowlands (Hartman and Johnson, 1984). Elevations range from sea level in the lowlands to 2,000 to 3,000 feet in the surrounding plateaus. The majority of the region is located between the Tanana River (on the north) and the Alaska Highway along the alluvial valley. The State Bison Range area lies adjacent to the region on the southern side of the Alaska Highway.

The Delta Junction analysis region lies in Alaska's continental climatic zone (Searby, 1968). It is characterized by great diurnal and annual temperature variations, the average January temperature being approximately -11 °F and the average July temperature being 57 °F. The mean annual temperature lies between 15 to 25 °F. There is little cloudiness and low humidity in this region. Surface winds are generally light and precipitation is generally low (Searby, 1968). The average annual precipitation is between 10 and 15 inches, with more than one-fifth of that precipitation falling as snow (Hartman and Johnson, 1984; White et al., 1965).

Soils

The soils of the Delta Junction analysis region are Tundra soils (Buckman and Brady, 1969). These soils are inceptisols whose agricultural capacity is limited by poor drainage resulting from permafrost. Rangeland in this region is underlain by discontinuous permafrost at depths of 1 to 3 feet below the active surface layer depending on ground cover. Permafrost in this region occurs simultaneously with the climax communities of black spruce trees. Once established, permafrost stops the infiltration of ground water and forces melt water and rain water to escape by surface drainage, thus creating a poorly drained boggy condition (Hartman and Johnson, 1984; Buckman and Brady, 1969).

Vegetation

The natural vegetation of the Delta Junction analysis region consists largely of ground cover species such as dwarf heath shrubs, mountain cranberry, mosses, dwarf dogwood, and bluegrass. Labrador tea and mountain cranberry are abundant on the cold, poorly drained lowlands. White spruce, black spruce, dwarf birch, and dwarf willow are common trees found in this region. During the winter months, vegetation is subjected to frozen soil and dry winds that cause extreme water loss and slow growth (White et al., 1965).

Terrestrial Wildlife

The animal most closely associated with this analysis region is the caribou. It is highly valued for food and migrates in large herds across Alaska each year. Other mammals common to this region are the moose, black bear, gray wolf, grizzly bear, wolverine, river otter, lynx, ermine, marten, Arctic ground squirrel, and snowshoe hare. Several species of shrew (Masked, Dusky, and Pygmy) and voles (Northern red-backed, meadow, tundra, yellow-cheeked, and singing) can also be found in this region (Whitaker, 1980). Bison were introduced to Alaska from Montana and now exist in increasing herds near Delta Junction in this region (White et al., 1965).

A large variety of birds inhabit this region--some as permanent inhabitants while others use it as a breeding or summer range. Permanent inhabitants include the Willow and Rock Ptarmigan, great horned owl, great gray owl, northern hawk-owl, hairy woodpecker, three-toed woodpecker, gray jay, common raven, black-capped and boreal chickadee, pine grosbeak, and rosy finch. Temporary inhabitants using the area as a breeding or summer range include the common and Arctic loon, red-necked and horned grebe, northern pintail, northern shoveler, green-winged teal, sharp-shinned hawk, northern harrier, golden eagle, common snipe, mew gull, short-eared owl, alder flycatcher, and rusty blackbird (Robbins et al., 1983). The American peregrine falcon is an endangered species in this region, and the Arctic peregrine falcon is listed as threatened.

Insects such as the mosquito, black fly, and gnat exist in the billions here and thrive on the high summer temperatures and poor drainage systems (White et al., 1965).

Water Resources and Aquatic Life

Availability of water may be lower than originally appears and difficult to obtain because of low temperatures that retain water in the form of ice or snow much of the year. Nonetheless, the Delta Junction analysis region generally has adequate water supplies. The annual water runoff in this area

is approximately 157 million acre-feet. Surface water is available from streams, lakes, and bogs. Many glacial streams exist in this region along the Tanana River. In areas where permafrost exists, no ground-water infiltration can occur, and water moves only through surface drainage (Hartman and Johnson, 1984; White et al., 1965). The aquatic species in this region include spotted ratfish, lake whitefish, coho salmon, chinook salmon, round whitefish, lake trout, Arctic grayling, Alaska blackfish, northern pike, lake chub, trout-perch, burbot, slimy sculpin, and several species of crab and shrimp (Boschung et al., 1983).

Human Populations

While both Fairbanks and Delta Junction have moderate to low populations (22,645 and 945, respectively), the Delta Junction analysis region that lies between these two cities is rangeland and is sparsely populated. This region averages 0.7 persons per square mile (Hartman and Johnson, 1984). Thus, very few humans should be at any risk in any grasshopper control program in this analysis region.

Agricultural Land Uses and Cultural Resources

Farming in Alaska is highly localized. This region has approximately 28,500 acres devoted to farming and approximately 81,500 acres of rangeland. Crops such as grains and vegetables do well in this region. Grains such as oats, barley, rye, and wheat survive the best, along with vegetables such as peas, carrots, and lettuce, and root crops such as potatoes, beets, radishes, and parsnip. However, shallow soils, poor drainage, and lack of fertility leads to costly farming and agricultural problems. An additional 10,000 acres on the south side of the Tanana River is owned by Alaska's Department of Fish and Game and is cleared and used for grazing bison. The remainder of the land in this region is in the lowlands and is used for pasture, and to a small extent, for silage crops (White et al., 1965). This analysis region has no important wildlife refuges, national monuments and national parks, and recreation or conservation areas.

Chapter 4
Environmental Consequences

INTRODUCTION

This chapter discusses the impacts of alternative methods of grasshopper and Mormon cricket control on the human environment of the western and Alaskan rangelands. Each control method was analyzed for its effects on soils, vegetation, wildlife, water quality and aquatic organisms, public health and occupational safety, air quality and noise levels, cultural resources, visual resources, and socioeconomics. The final section of this chapter presents a discussion of cumulative and synergistic environmental effects, energy requirements, unavoidable environmental effects, short-term uses versus long-term productivity, and irreversible and irretrievable commitment of resources.

The impacts of grasshopper control methods on endangered and threatened species are discussed in detail in a Biological Assessment prepared by APHIS for the 17 western States and Alaska (USDA, 1987). Those impacts are outlined only briefly here in the appropriate sections on vegetation, wildlife, and aquatic organisms. The Biological Assessment proposes programmatic protection measures to prevent adverse effects to any federally listed endangered or threatened species that may occur in proposed treatment areas. These measures may be subject to modification in the Biological Opinion that will be prepared by the U.S. Fish and Wildlife Service. APHIS is committed to comply with all protection measures developed in consultation with the U.S. Fish and Wildlife Service. They will be available for review in the Biological Assessment (available from APHIS) and the Biological Opinion (available from the Fish and Wildlife Service). In accordance with 40 CFR 1502.20, the findings of the Biological Assessment are incorporated by reference into this EIS.

Federally listed species, candidate species for Federal listing, State-listed species, and other species of concern, such as limited range or unstable populations, will be addressed in site-specific environmental assessments tiered to this EIS, and site-specific protection measures will be developed as needed.

To determine the effects of the chemical methods on wildlife, aquatic organisms, and human health, a risk assessment involving three steps--hazard analysis, exposure analysis, and risk analysis--was conducted. Appendix A describes in detail the hazards of malathion, carbaryl, and acephate to humans, wildlife, and aquatic organisms. Appendix A also describes the toxicity of the diesel and petroleum oils used in the

application of carbaryl and the toxicity of methamidophos, a degradation product of acephate. Appendix B presents a review of the environmental fate properties of the three chemicals, diesel and petroleum oils, and methamidophos, and the details of the exposure and risk analysis calculations for wildlife, aquatic organisms, and humans. The risk analyses for each element are summarized in this chapter.

To ensure that no risks are underestimated, this EIS examines both the effects of the use of the alternative insecticides under routine operational conditions, as well as the effects of unlikely, but nevertheless, possible accidents such as spills on workers, accidental spraying of a body of water, and a jettison of insecticide into a reservoir. Conservative assumptions are used throughout this analysis so that no potential effects from the use of insecticides that have any likelihood of occurring will be overlooked.

The impacts on each resource element are discussed separately. However, the interrelatedness of these environmental components, as illustrated by the potential routes of exposure to control chemicals shown in figure 4-1, must be kept in mind when potential impacts are examined. For example, the first section addresses the impacts of alternative grasshopper control methods on the soil. Much of the discussion, however, is also pertinent to impacts on vegetation, wildlife, aquatic systems, and humans.

There is a two-part discussion of impacts under each resource element. The first part examines the impacts of each control method; for example, the use of malathion spray. The second part examines the impacts under the three control alternatives: no action, chemical control, and integrated pest management. The discussion under each alternative draws on the more detailed presentation under each control method to form conclusions.

For the purpose of establishing a baseline for the impacts analysis, it is assumed that no control operations occur under the no action alternative. However, it should be kept in mind that under the no action alternative, the grasshopper control activities by other Federal agencies, States, and private individuals could continue and could result in impacts similar to those discussed under chemical controls and integrated pest management. In fact, individuals or other groups may use more toxic chemicals than those proposed for use by APHIS, and they would not necessarily follow the strict operational procedures designed by APHIS to minimize impacts.

Throughout this chapter, the operational procedures required under APHIS' cooperative grasshopper management activities are described in relation to the impact they are designed to

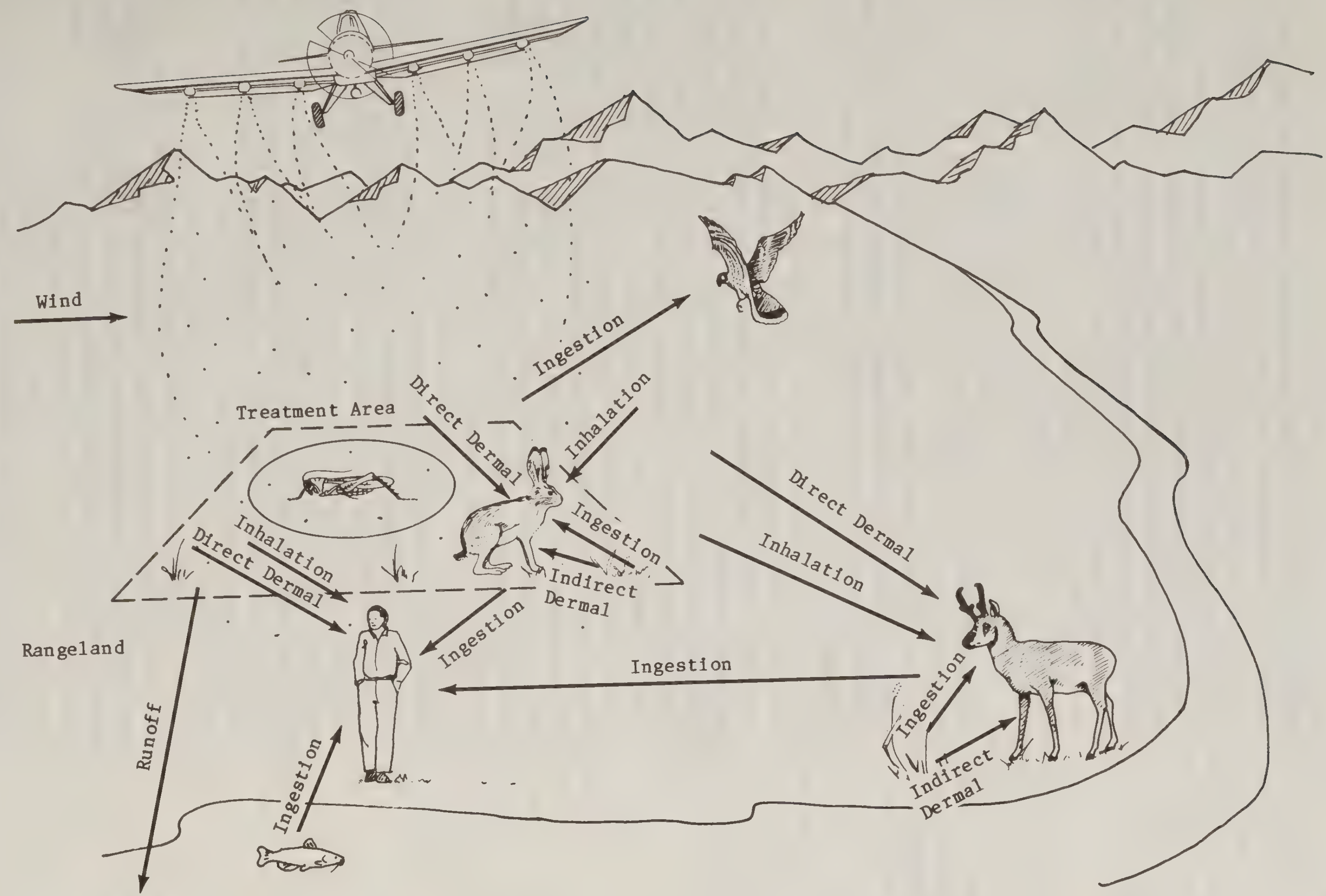


Figure 4-1--Sources of exposure and interrelationships among environmental components of the rangeland ecosystem

mitigate. All required operating procedures and recommended mitigation measures are listed in tables 2-1 and 2-2.

As explained in chapter 2, research on other chemical formulations, biological controls, and on cultural/mechanical methods will continue under the IPM pilot project. As any of the methods in research become operational, they will be analyzed in a supplement to this EIS for incorporation into APHIS' cooperative control program.

SOILS

Impacts of Grasshopper Control Methods

Chemical Controls

This section summarizes the potential effects of grasshopper control chemicals on the soil. Specific details of laboratory and field studies concerning these effects are given in appendix B.

The potential impacts of grasshopper control chemicals on the soil could be direct or indirect. The chemicals would directly affect the soil if they persisted in the soil environment and altered the soil's chemical or physical characteristics in a way that decreased the soil's ability to support a plant community. Indirect effects could include losses in populations of soil organisms, both microorganisms and higher forms. Soil microorganisms are essential to the breakdown and incorporation of organic matter. Higher animals, from insects and earthworms to burrowing mammals, are largely responsible for soil granulation, transfer, aeration, and drainage (Buckman and Brady, 1969).

A beneficial indirect effect of chemicals would be the maintenance of plants that provide soil protective cover through reduction in grasshopper populations. Plant cover protects the soil from the drying effects of the sun, and plant root systems hold in place the soil that may otherwise be eroded by rain or wind. Any less effective grasshopper control methods could result in the removal of more protective plant cover and hasten the erosion process.

It is important to note that organophosphorus insecticides (malathion and acephate) and carbamate insecticides (carbaryl) are relatively nonpersistent in the environment. These chemicals generally persist from only a few hours through several weeks to months (Doull et al., 1980).

Malathion ULV Spray. Because of the low amount of malathion used per acre and its rapid degradation, the impacts on the soil of spraying malathion to control grasshoppers should be negligible. Malathion degrades rapidly in the soil (half-life in soil is 0.5 days), with no accumulation of malathion or its

degradation products (Curley and Donohue, 1986). In addition, soil microorganisms such as Pseudomonas and Trichoderma can metabolize malathion and its metabolites (Matsumura and Baush, 1966). Inorganic degradation may be more important in those western soils that are alkaline and have lower organic matter content. Reduced populations of some soil insects and arachnids were observed after malathion application; however, normal population levels were subsequently reestablished (Giles, 1970).

Carbaryl Spray. Because of its low application rate and quick breakdown, carbaryl spray from grasshopper control programs should not significantly affect soils. Carbaryl retention by soils varies depending on soil types, with soils containing a higher organic content able to absorb several times more than sandy soils (Dolinger and Fitch, 1979). The half-life of carbaryl ranges from 3 to 8 days under normal conditions (Johnson and Stansbury, 1965). In most cases, carbaryl should not be detected after 40 days (Dolinger and Fitch, 1979). Decomposition by microorganisms is the predominant route of degradation, producing few toxic intermediate breakdown products that, in turn, degrade rapidly. Soil microorganism densities were found to be slightly affected following application of carbaryl, but recovery was seen 3 weeks later. Soil mite density was unaffected (Moulding, 1972).

Carbaryl Bait. Under normal conditions, carbaryl bait should have fewer effects on soil and soil organisms than carbaryl spray. Bait would either be eaten or remain on the ground. Carbaryl on the ground would tend to remain on the bait and would not likely seep into the soil. Rain shortly after application of the carbaryl bran bait might wash some carbaryl off into the soil, with effects similar to those of carbaryl spray. However, operational procedures (see table 2-1) recommend that carbaryl bait not be used when precipitation is imminent, so such effects are unlikely.

Diesel Oil and Petroleum Oil. The dispersion of a low dosage of petroleum oil into the environment would result from the use of Sevin 4-Oil (49 percent carbaryl by weight, 46.3 percent petroleum oils by weight) diluted up to 4 to 1 by volume with diesel oil, as suggested for more efficient aerial application and longer residual insect control. Petroleum oils should have a negligible impact on soils because of the small amounts being sprayed. Because lighter components of diesel oil tend to evaporate quickly, most of the components remaining in the soil will be those with heavier molecular weights. Once in soil, they should evaporate slowly or undergo biological degradation. None of these components are likely to be at concentrations high enough to affect the soil directly, to be toxic to soil organisms, or to affect ground water.

Acephate Spray. Because its application rate is low and it degrades rapidly, acephate spray from grasshopper control programs would have minimal effects on soil. Acephate has a short half-life in soils (4 to 10 days) because of its high biodegradability (Lambert, 1985). It is degraded primarily by soil microorganisms (Tutass, 1968). About 90 to 95 percent of acephate degrades directly into innocuous salts (Tucker, 1972), while 5 to 10 percent degrades to methamidophos (Leary and Tutass, 1968), which does not bioconcentrate (Chevron, 1973). Both acephate and methamidophos are readily removed by water in soil with little or no retention by the soil particles (Tucker, 1971; Tutass, 1968). After tests by Focht and Joseph (1974) and later by Dutcher and Sheppard (1981), researchers concluded that acephate had no observable adverse effects on soil organisms. Organism populations that were slightly depressed following acephate use recovered to pretreatment levels within 1 month. There appears to be no soil buildup of acephate or its metabolites from one season to the next (USDA, 1976).

Biological Control

Nosema should have no adverse effects on soil or soil organisms because it is species-specific to grasshoppers. Evidence shows that, although Nosema persists in the soil for more than a year, it does not adversely affect soil organisms. Soil organisms, such as beetles that eat contaminated grasshopper eggs, have been shown to be unaffected by Nosema, thus demonstrating its species-specific nature.

Impacts of Grasshopper Control Alternatives

No Action

The no action alternative could result in adverse effects on the soil from significant vegetation losses during heavy grasshopper infestations. Loss of plant root systems that hold soil in place and increased sunlight on the ground surface (causing soil dessication) could lead to soil erosion by wind and water.

Soil organisms also would be affected by the increased soil temperatures and soil disturbance from erosion. Erosion could cause a steady decline in the amount of organic matter present in the soil, and recovery may take considerable time. In severe cases, burrowing animals, such as mice and rabbits, would be affected by the disintegration of burrows caused by erosion of the soil layers. Insect species and spiders that live in the soil have shown marked population decreases as a result of erosion and heavy losses of vegetation in highly infested areas (Smith, 1940). This may be a result of the buried eggs of such insects being destroyed.

The erosion that results from loss of vegetation from severe grasshopper infestations would be greatest in the tall- and short-grass prairies and the California grasslands. Without the branching root systems of the grasses, there would be nothing to hold the soil in place. In 1934 and 1935, the loss of these root systems is believed to have led to large-scale erosion and soil structure damage in the Great Plains and ultimately to the Dust Bowl of the 1930's (Owen, 1971). In the mountain and plateau regions, soil loss would depend upon varying vegetational cover and steepness of slopes. In the desert region, where vegetation is already relatively sparse, erosion potential caused by loss of ground cover to grasshoppers would be even greater.

Chemical Control Alternative

Under the chemical control alternative, minimal adverse effects on the soil would be expected. Malathion, carbaryl, and acephate remain in the soil for only a short period (half-lives vary between 0.5 and 10 days). There would be no bioaccumulation or concentration in food chain levels of parent compounds and their metabolites. While some soil microorganism populations decrease after chemical treatments, recovery should be rapid and no long-term significant changes in population density would likely be found. Positive effects on the soil of this alternative would accrue by reducing vegetation lost to grasshoppers, thereby protecting soils and the watershed.

IPM Alternative

The integrated pest management alternative allows the use of chemical, biological, or cultural/mechanical methods (when they become available) based on site-specific factors.

Because the increased use of nonchemical controls would be expected under IPM, the short-term impacts on soil microorganisms discussed under chemical use should be lower than those under the chemical control alternative.

VEGETATION

Impacts of Grasshopper Control Methods

Chemical Controls

The potential effects of the chemicals on vegetation, apart from the protection afforded by removing plant-eating grasshoppers, would include any direct toxicity to vegetation (phytotoxicity), effects on plant reproduction caused by removing insect pollinators, and effects on other plant-eating organisms such as burrowing mammals. These latter two effects are discussed in the wildlife section of this chapter. Regarding phytotoxicity, it appears that, although the three chemicals are slightly phytotoxic to certain ornamental and

fruit-bearing species, they are not likely to injure range vegetation in APHIS' grasshopper control activities.

Malathion ULV Spray. Malathion is registered for use on a wide variety of fruit trees, ornamental plants, vegetable plants, and field crops (including corn, wheat, and cotton) (American Cyanamid Company, 1986). Some varieties of plants, including string beans, nectarines, apples, pears, cherries, grapes, cucurbits, and some ornamentals are harmed by malathion. However, no evidence of phytotoxicity was observed in a forested watershed after aerial spraying with malathion at 0.81 kg/ha (0.72 lb active ingredient per acre) (Giles, 1970), which is higher than the 0.58 lb a.i./acre (8 oz a.i./acre) currently used in APHIS' cooperative control program.

Carbaryl Spray. Carbaryl is registered for use on corn, wheat, soybeans, grass, hay, rangeland, and pastureland, as well as on various other vegetable and fruit crops (U.S. EPA, 1984a). Carbaryl can injure some species, such as Boston ivy, Virginia creeper, and maidenhair fern (Union Carbide, 1982), as well as apples, pears, and watermelons (Thomson, 1979). A small degree of stunting has occurred in conifer seedlings treated with carbaryl (Sutherland and Woods, 1977), and excess dosages of carbaryl may retard germination of grasses (Thomson, 1979). Nevertheless, carbaryl is nontoxic to most plants when applied at label rates (Amer, 1965). The maximum application rates for pasture and rangeland of 2 lb a.i./acre and for fruits and vegetables ranging from 1 to 4 lb a.i./acre (U.S. EPA, 1982a) are all above the prescribed rate of 0.5 lb a.i./acre of carbaryl for grasshopper control.

Carbaryl Bait. Bran baits would not readily settle onto plant surfaces during application and any contact with leaf surfaces would generally be of very short duration. The 5-percent concentrations of carbaryl on the bran flakes would not be toxic to plants because carbaryl is nontoxic to most plants when applied at label-recommended rates.

Diesel Oil and Petroleum Oils. If Sevin 4-Oil is used, petroleum oil would be dispersed into the environment because the insecticide contains petroleum oils and is mixed with a diesel oil carrier for application. Diesel and petroleum oils should have negligible effects on rangeland vegetation. Although diesel oil depresses photosynthetic and respiration rates leading to plant cell death (Wedding et al., 1952) and is commonly used as a local weed suppressant in agriculture, the low dosage rates at which the oils will be applied in APHIS' grasshopper control programs should eliminate the potential for significant adverse effects on vegetation.

Acephate Spray. Acephate should have no significant effects on rangeland vegetation. Acephate's (brand Orthene 75S) registered uses include beans, celery, cotton, lettuce, winter wheat, pastures, and rangeland (Chevron, 1982). It was non-phytotoxic or of low toxicity in tests with many varieties of ornamental and tropical plants when used at application rates similar to those proposed for use in the current program. The prescribed treatment rate of 0.094 lb a.i./acre of acephate for the grasshopper control program is at the lower range of the registered maximum rates of 0.094 to 0.125 lb a.i./acre (U.S. EPA, 1982b).

Biological Control

Nosema is not toxic to plants and no direct toxic effects to vegetation are expected from its use. However, because Nosema does not reduce grasshopper populations, and thus vegetation loss, as quickly as the chemical methods, an indirect effect of Nosema could be some increased damage by grasshoppers to rangeland vegetation and adjacent crops in the year of application.

Potential Impacts on Endangered or Threatened Plant Species

Concern has been expressed that insecticide treatments might prevent pollination of endangered and threatened plant species. Some of these species are self-pollinating and others reproduce by bulbs, corms, or rhizomes. Species that require pollination by insects may bloom before or after a grasshopper treatment. The three chemicals considered for use by APHIS are highly toxic to bees that may be pollinators of endangered or threatened plants. Operational procedures have been developed to protect honey bees (see table 2-1), but wild pollinators could be adversely affected.

Programmatic protection measures to protect federally endangered and threatened plant species from direct effects of spraying will be developed, as needed, in consultation with the U.S. Fish and Wildlife Service. The 1987 Biological Assessment prepared by APHIS contains proposed protection measures for endangered and threatened plant species in the event that potential impacts to wild pollinators could adversely affect the reproduction of these plants. Field level conferences with the Fish and Wildlife Service will take place to obtain the necessary distributional and biological data on these plant species for site-specific analysis.

Impacts of Grasshopper Control Alternatives

No Action

In any given year, largely depending on weather conditions, heavy populations of grasshoppers are likely in some or all of the 17 western States and Alaska. The results of the 1985 adult grasshopper surveys indicate that approximately 59.3 million acres of rangeland had the potential for economically

important infestations (eight or more grasshoppers per square yard) in 1986.

Grasshoppers at population densities below these infestation levels are generally selective feeders and eat only parts of the preferred host plants. However, during heavy infestations, virtually all vegetation, including grasses, forbs, shrubs, and trees, is threatened. The damage could be so severe that in areas of heaviest infestation all grasses and forbs could be destroyed and plant growth could be retarded for several years. Endangered or threatened plant species that are of limited quantity and distribution could suffer severe consequences as a result of grasshopper outbreaks.

In areas of sparse vegetation and dry climate where plants may not recover from grasshopper outbreaks as quickly as in areas of dense vegetation and climates suited to more rapid plant growth, impacts of no control would be more severe.

Chemical Control Alternative

The chemicals proposed for use in grasshopper control are generally nonphytotoxic--that is, they are generally not poisonous to plants--and direct spraying is not expected to have any adverse impacts on vegetation. (For this reason, an analysis of drift effects on vegetation was not considered necessary.) Chemicals act quickly to reduce grasshopper infestations; thus, damage to vegetation from grasshopper foraging would be minimized. A 500-foot buffer zone will be maintained around all crops for which an aerial ULV insecticide being applied is not registered. Thus, no adverse effects to crops for which the pesticide is not registered should occur.

The efficacy of the chemicals and their effects on vegetation may differ somewhat from region to region because of differences in temperature and moisture, vegetative coverage, and vegetative types. In areas such as the tall-grass prairie where a high percentage of vegetative cover exists, spray treatments would more likely be intercepted by foliage than in areas of sparse vegetation, such as the desert. As a result, fewer grasshoppers would receive direct exposure to treatments and would have to ingest contaminated vegetation to be affected. Acephate, which is more effective through direct contact with grasshoppers, would therefore be less useful in areas of greater vegetative cover. Carbaryl and malathion, which affect grasshoppers primarily through their ingestion of foliage, would be less efficacious in areas of sparse vegetation (Pfadt et al., 1970; Lloyd et al., 1974).

Plants would be exposed to chemicals for a longer period of time in areas, such as the desert region, where low humidity

would slow degradation of chemicals. In warm moist areas, such as the tall-grass prairie, where degradation of chemicals would occur more rapidly, exposure to chemicals in the environment would be brief and fewer impacts would occur.

IPM Alternative

Under the IPM alternative, the total amount of chemicals used in a given year would be less than that used under the chemical control alternative. No adverse impacts to vegetation are expected from the use of any of the chemicals under this alternative.

Nosema would not cause adverse effects to vegetation. However, because it is slower acting, some damage to rangeland and nearby crops may occur before grasshopper populations are significantly reduced.

As improvements in predictive modeling and the early introduction of Nosema help prevent grasshopper outbreaks, adverse impacts on vegetation from grasshopper outbreaks would be greatly reduced.

CHEMICAL RISK ASSESSMENT

To assess the impacts of the use of the three alternative insecticides on wildlife, aquatic organisms, and human health, a risk assessment was conducted. This section describes the methodology used in the risk assessment. The results of the risk assessment are discussed in the three subsequent sections. Detailed information and calculations used in the risk assessment are presented in appendixes A and B.

The risk assessment consists of the following steps:

First, the <u>hazard analysis</u> answers questions regarding the toxic (poisonous) properties of each of the insecticides, the doses that are deemed safe, and the doses that might cause harm. Most of the information used to answer these questions comes from laboratory tests that use mammals. Other sources include studies of human exposures and research involving other organisms.

The <u>exposure analysis</u>, the second step, determines what organisms in the environment are likely to be exposed to the insecticide as a result of spraying and how much insecticide is likely to enter their bodies. Environmental components (people, wildlife, livestock, and so forth) can be exposed in several ways and to differing amounts of the chemicals. The exposure analysis describes how these components might be exposed.

The third step, the <u>risk analysis</u>, addresses how human health or that of nontarget organisms could be affected by actual

spraying operations. This question is answered by comparing the results of the first two steps. That is, the estimated doses (the amounts that might enter environmental components) are compared with the doses found to be safe or harmful to health.

An important part of the risk assessment in the hazard and exposure analysis stages is the determination of whether there is incomplete or unavailable information that is necessary to prepare the assessment. As part of the pesticide registration process under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), EPA has identified specific gaps in the data on acephate and carbaryl.

With regard to acephate, the following data gaps exist: residue studies to determine the fate of acephate and its metabolite methamidophos in succulent beans, dried beans, soybean oil, and soybeans; and a dairy cattle feeding study to determine the fate of acephate and methamidophos residues during milk pasteurization. Other data gaps include applicator exposure studies, dermal penetration data, spray drift data, and reentry data. With regard to carbaryl, EPA has identified the need for a 1-year dog feeding study; additional residue data for cotton, alfalfa, grass, and processed food commodities; and additional data for oats, rye, and barley.

The Guidance for the Reregistration of Pesticide Products Containing Malathion is scheduled for issuance in 1987. EPA has provided information to APHIS concerning the toxicity of malathion (see appendix A). Where EPA-reviewed studies on malathion were not available, studies from the scientific literature were cited.

EPA has indicated that none of the pesticides currently used by APHIS contain inert ingredients of toxicological concern. However, EPA has included petroleum hydrocarbons on its list of inerts of toxicological concern (U.S. EPA, 1986c). Because carbaryl is commercially formulated with petroleum oil, and because diesel oil may be used as a carrier for carbaryl, APHIS has incorporated a risk assessment on diesel and petroleum oils in its analysis of impacts on each resource element.

In addition, EPA has indicated that the aqueous formaldehyde used as a preservative in the Sevin XLR Plus formulation of carbaryl is an inert of toxicological concern and that it is proposed to be reclassified as an active ingredient (U.S. EPA, 1987). Although APHIS does not currently use Sevin XLR Plus in its control program, it may be used in future years. For this reason, the risks associated with formaldehyde are included in the human health section of this chapter. Based on the findings of EPA (1986d) that use of formulations containing less than one percent formaldehyde are not expected

to pose risk to fish and wildlife, and the low concentration that would be used in grasshopper control, a risk assessment for the formaldehyde constituent of Sevin XLR Plus is not presented for wildlife or aquatic species.

APHIS believes that the incomplete information identified in EPA's FIFRA registration process is not essential to a reasoned choice among alternatives, as described by the regulations for implementing NEPA (40 CFR 1502.22). That is, the information on each of the chemicals that is currently available provides a sound basis for analyzing the impacts of their use under conditions proposed for APHIS grasshopper control programs. Further, APHIS believes that the risk assessment conducted in this EIS is conservative enough to account for possible impacts attributable to any of the issues identified above. Risk assessment methods generally accepted in the scientific community have been used to evaluate impacts. Where appropriate, opposing views regarding potential impacts of the chemicals have been included.

Hazard Analysis

Determining Toxicity

The first step in the risk assessment was to determine the inherent toxicity of a chemical considered for use. Toxicity is the capacity of a substance to cause harmful effects to an organism. Table 4-1 summarizes the availability of relevant toxicity data on the three insecticides. Appendix A discusses the results of available laboratory and field toxicity studies.

Toxicity is routinely determined by use of conventional tests on laboratory animals. Although the results of animal tests cannot be translated directly into expected effects in humans, they are commonly used as toxicity reference levels in analyzing potential human health risks.

There are two general categories of responses of an organism to toxic chemicals: threshold responses and nonthreshold responses. With threshold responses, a certain amount of the chemical must be in the animal's system to cause a given effect such as weight loss, birth defects, and the like. Nonthreshold responses, such as cancer, are believed to result from exposure to as little as one molecule of a chemical.

Toxic Effect Levels and Threshold Responses

The toxic effect levels considered in the analysis of wildlife and aquatic species risks are the median lethal dose (LD_{50}) and the median lethal concentration (LC_{50}). The median lethal dose is the amount of chemical in a single (acute) dose necessary to kill 50 percent of a group of laboratory test animals (the dose that, on average, will kill an individual test organism). The LD_{50} is also expressed in

Table 4-1--Availability of relevant effects information

Type of Effect	Acephate	Carbaryl	Malathion
Acute toxicity	+[1]	+	+
Systemic toxicity	+	+	+
Epidemiology	-[2]	*[3]	+
Teratogenicity	+	+	+
Mutagenicity	+	+	+
Carcinogenicity	+	+	+
Human Exposure	+	+	+
Nontargets	+	+	+
Environmental fate			
Animals	+	+	+
Vegetables	+	+	+
Water	+	+	+

[1] +Indicates data available.
[2] -Indicates no data found.
[3] *One study dealing with birth defects.

milligrams per kilogram (mg/kg) and usually is available for oral or dermal test animal exposures. For aquatic organisms, an LC_{50} is normally established. This is the concentration in water that is lethal to half the test organisms. The LD_{50}'s, and LC_{50}'s are used directly in the risk analysis of effects on wildlife and aquatic species.

The evaluation of human health effects is more conservative. It is based on lower dosing levels in laboratory animals that were used to set threshold response levels. The dividing line between the amounts (doses) that have no effect and those that do is called the threshold. Threshold responses in laboratory animal tests are reviewed in the hazard analysis to focus on the highest doses that cause no ill effects. These levels are called the no-observed-effect levels (NOEL's). The NOEL's are expressed in milligrams (mg) of chemical per kilograms (kg) of body weight. This common unit (mg/kg of body weight) enables comparisons between different test animals and different effects. To ensure that risk is not underestimated, the NOEL used in this risk analysis for each effect of each chemical is the lowest observed in the available studies.

Because of biological differences between test animals and humans, NOEL's derived from animal studies usually are reduced by a safety factor when estimating safe doses for humans, to err on the side of caution. Safety factors commonly range from 10 to 1,000. EPA and the World Health Organization (WHO) both use safety factors to establish safe doses for various chemicals. For each chemical, the safety factor that is used depends on how closely the animal studies can be applied reasonably to humans. The number arrived at when the safety factor has been applied to the NOEL is called the acceptable daily intake (ADI). The ADI is considered to be the maximum dose of the chemical that can be taken every day over a person's lifetime without any adverse effects. The relationship between NOEL's, ADI's, and LD_{50}'s is illustrated in figure 4-2.

NOEL's and ADI's serve as starting points for evaluating the health risks associated with the use of pesticides. If the exposure analysis shows that the expected dose to humans will be less than or equal to the ADI, then the dose is considered safe for most people.

LD_{50} - Acute lethal dose. One-time or short-term dose lethal to 50 percent of treated animals

Threshold - Long-term dose level at which adverse effects first occur.

NOEL - No-observed-effect level. Long-term dose that does not result in apparent adverse effects in test animals.

Safety Factor - Factor applied to selected NOEL to set safe lifetime dose to humans.

ADI - Acceptable daily intake. Maximum dose that a person could safely take every day throughout lifetime without harm to health.

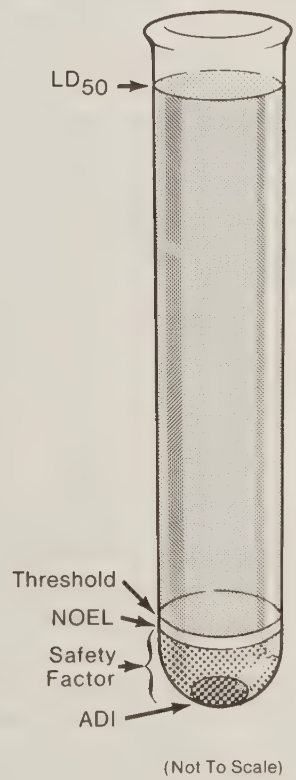


Figure 4-2--Relationship of NOEL's, ADI's, and LD_{50}'s

It is important to keep in mind that the NOEL's used in this analysis are from studies that involve repeated daily exposure over a considerable length of time. Also, ADI's are considered to be doses that can be taken safely every day for an entire lifetime. Yet most potential exposures from grasshopper projects occur at a much lower frequency and are short-term exposures. A member of the general public would be exposed a maximum of 10 times in 70 years, and a pesticide worker would be exposed an average of 20 days per year. Therefore, comparing the estimated exposures to ADI's and NOEL's gives a biased picture of the risks involved. The error is on the side of exaggerating the risks.

Nonthreshold Responses

Certain effects, such as the occurrence of cancer and mutations, are considered to be nonthreshold responses. The hazard assessment used for cancer has two steps. The first is to see if there is evidence that the chemical in question could cause cancer. The second is to determine the chemical's cancer potency; that is, to determine the probability of getting cancer from different doses. Because no known cases of human cancer have been caused by any of the three chemicals being considered, data on laboratory test animals were used. Where tests have indicated, through the production of malignant or benign tumors, that a chemical might cause cancer in mammals, a mathematical model was used to determine its cancer potency.

Various models (or formulas) can be used to determine cancer potency. For this analysis, a linear model was used. The linear model assumes that a steady increase in dose will result in a steady increase in the likelihood of getting cancer. While this model is overly simplistic, it exaggerates, rather than understates, the chances of a person getting cancer. The model states that the probability of cancer is equal to the cancer potency times the person's average daily dose of the chemical over his or her lifetime.

The potential for mutations (changes) in reproductive cells--called germ cells--is also considered, although no generally accepted model exists for determining the risk of mutations. While cancer can be caused by changes in any cell, and substances that cause cancer thus have many more possible targets in the body, heritable mutations (those that can be passed on to offspring) are caused only by changes in germ cells. For this reason, it is assumed that the risk of heritable mutations will be no greater than the risk of cancer. Thus, use of the linear cancer model to estimate the risk of heritable mutations should greatly overestimate such risks.

Exposure Analysis

Method for Determining Exposure

Exposure occurs when a chemical enters the environment and comes into contact with an organism. Exposure, in turn, leads to a dose--the amount that actually enters the organism's living system (body). The exposure analysis examines the amount of pesticide applied; how wildlife, aquatic organisms, or humans might become exposed (inhalation, dermal, oral, or immersion routes of exposure); who would be exposed; and what the resultant dose would be. Because all three chemical insecticides and the diesel/petroleum oils used with carbaryl are aerially applied, certain aspects of exposure, such as the type of exposure (inhalation, dermal, or oral), who would be exposed, and conditions of exposure, are shared by all.

The exposure analysis was conducted using scenarios that are simplified mathematical models of the relationships among various components of the environment (see figure 4-1); that is, the relationships between wildlife, aquatic species, and humans, and their potential avenues of exposure to the pesticides (air, water, food, soil). Appendix B contains the details of the exposure analysis.

To determine wildlife and human doses by means of dermal exposure, the body surface area for wildlife and the amount of exposed skin for humans were estimated. The amount of insecticide estimated to be deposited on the skin multiplied by a chemical-specific penetration rate gave an estimate of the dermal dose. To estimate inhalation doses, aerial concentrations, duration of exposure, and species-specific breathing rates were used. Oral doses were determined by setting a hypothetical diet for animals and humans and by estimating contamination levels in each diet item. Aquatic species were assumed to be exposed to an estimated concentration of insecticide in a body of water.

Two types of scenarios were used in the human and aquatic species exposure analyses:

(1) Routine scenarios in which the exposures and doses that are estimated may be reasonably expected to occur under normal insecticide application conditions.

(2) Accident scenarios in which the estimated exposures and doses are those that could possibly occur in the unlikely event of a minor accident, such as a worker spilling pesticide on his clothing, or a major accident, such as the jettison of a load of insecticide mixture into a reservoir used for public drinking water.

This risk assessment also addresses the potential effects of multiple applications of malathion and carbaryl to control

rangeland grasshopper populations that threaten croplands. Acephate pesticide labels prohibit retreatment of rangelands within the same season. However, malathion and carbaryl could be reapplied after a minimum interval of 4 weeks.

Wildlife Exposures

Because no analysis could realistically estimate doses to every wildlife species that might be present in a rangeland area, a set of representative species was used. The representative species were chosen as typical members of the classes of animals and feeding niches found on most western rangelands. The representative wildlife species include migratory and game birds, a raptor, small mammals, ungulates, a carnivore, reptiles, and an amphibian.

The representative wildlife species used in the analysis were chosen based on the information reviewed in the preparation of chapter 3, in particular Brown (1985). The representative species are as follows:

Birds
- Lark Bunting
- Sage Grouse
- Bobwhite Quail
- American Kestrel

Mammals
- Grasshopper Mouse
- Black-tailed Jackrabbit
- Pronghorn
- Beef Cow
- Coyote

Reptiles
- Horned Lizard
- Yellow-bellied Racer

Amphibian
- Rocky Mountain Toad

Exposures to wildlife and resultant doses were estimated assuming animals are present on a spray site during a routine control operation and are directly sprayed. (Detailed exposure calculations are given in appendix B.) It was assumed that beef cattle are also present on the spray site.

No accident scenarios were considered necessary to evaluate risk to wildlife. Any accidents that might occur over land areas, such as the jettison of a load of insecticide or a spray aircraft crash, would have serious immediate but highly localized impacts that would include fatalities of wildlife sprayed or on the crash site. No population effects would occur, and an immediate cleanup of the site would ensure restoration of the original biological community.

Doses for dermal, inhalation, and ingestion routes of exposure were estimated assuming the chemical application rates were 0.58 lb/acre for malathion, 0.50 lb/acre for carbaryl, and 0.094 lb/acre for acephate. It was assumed that 337.4 mL of a

mixture of diesel oil and petroleum oil are applied per acre with each carbaryl spraying.

Dermal wildlife exposures were estimated by assuming that an animal receives an exposure over its entire body surface at the per-acre application rate. An additional amount of chemical on the animal's body surface is assumed to come from its movement through treated vegetation. Oral doses were estimated for mammals through grooming their fur and for birds through preening. Inhalation exposures were estimated by multiplying an animal's estimated breathing rate by the assumed insecticide concentration in the air after spraying. Ingestion exposures for each animal were determined for a single day's diet of contaminated food items (seeds, grass, grasshoppers, other insects, other animals) and for an estimated amount of contaminated drinking water.

The total of the dermal, oral, and inhalation doses gave a single day's acute dose for comparison with the laboratory hazard reference doses (LD_{50}'s) for the most closely related laboratory test animal. Because the three insecticides degrade relatively rapidly and do not bioaccumulate, only acute effects estimated on the day of spraying were analyzed.

Aquatic Organism Exposures

Exposures of aquatic organisms were assumed to occur during routine scenarios from off-site drift of insecticide beyond 500 feet (the specified buffer distance for bodies of water supporting higher aquatic life) into a small stream 1 foot deep and into a small pond 4 feet deep. The aquatic concentrations reached through complete mixing in the water were then compared with the laboratory LC_{50} levels in the aquatic organism risk analysis. Accidental scenarios for estimating impacts to aquatic organisms included direct spraying of a 16-acre reservoir 8 feet deep, jettisoning of 200 gallons of spray mixture into a reservoir of the same dimensions, and contamination of a reservoir of the same dimensions with runoff from a thunderstorm over a 500-acre watershed. The accidental scenarios assume that the required operational procedures prescribing a 500-foot no-spray buffer zone around specified water bodies and prescribing no spraying when rain is imminent are not met.

Representative aquatic species were selected to represent those commonly found in cold-water and warm-water environments in the western United States (based on Boschung et al., 1983; Pennak, 1978; and Klots, 1966). These species also represent a range of organisms in an aquatic food chain, from small insects and crustaceans to large predatory fish.

The representative aquatic species used in the analysis were the following:

Fish	Invertebrates
Rainbow Trout	Crayfish (*Orconectes*)
Bluegill	Stonefly (*Pteronarcella*)
Channel Catfish	Scud (*Gammarus* sp.)
Fathead Minnow	

Human Exposures

The human population at risk of being exposed to insecticides in grasshopper control operations includes both workers and the public. Workers are those who are directly involved in the operations. Members of the public include those who may be present during or immediately after the spraying operations or who may receive a dose through contaminated drinking water or food items even though they are not present during a spray operation.

Scenarios were developed as a means of estimating exposures. The exposure scenarios were intended to represent a full range of the kinds and magnitude of exposures that could occur, while restricting the calculations to a manageable number of cases. Table 2-1 in chapter 2 lists the standard operating procedures that are required in all APHIS control programs to protect workers and the public. However, some assumptions used in the exposure analysis are based on noncompliance with these procedures. To avoid underestimating exposures, many parameters and assumptions were chosen so that calculated exposures would overestimate exposure. Average human exposures would most likely be lower. The details of exposure estimation are given in appendix B. Some of the more important factors are summarized here.

The human exposure scenarios are based on treatment blocks, each of which represents a rangeland area sprayed on a single day in a single contiguous unit. The size of each area is typical for spraying under favorable weather with four spray aircraft. The area is assumed to be 20,000 acres for malathion, 15,000 acres for carbaryl, and 12,000 acres for acephate. The total volumes of spray used in the scenarios are 8 fluid ounces (0.58 lb a.i.) per acre for malathion, 20 fluid ounces (0.5 lb a.i.) per acre for carbaryl, and 32 ounces (0.094 lb a.i.) per acre for acephate.

Routine exposures to pilots and mixer/loaders were estimated from a field monitoring study that measured pesiticide residues from denim patches and air-sampling tubes attached to workers. Routine dermal and inhalation exposures for both workers and the public at 500 feet from the spray-site were based on field tests of insecticide spraying in relatively

steep terrain where atmosphere mixing of the sprayed material is enhanced by topographic variation. Drift and resultant dermal and inhalation exposure on flatter lands would not be as great. Dermal doses were calculated for an adult, assuming 2 square feet of exposed skin. Inhalation doses were calculated for a breathing rate that represents moderate activity.

Accidental doses were calculated for workers assuming that one-half liter of insecticide concentrate (or mix for acephate, which is formulated and sold as a powder) gets on the worker's skin and clothing. This amount of liquid would wet most of the worker's body.

Oral doses for members of the public were calculated based on consumption of one of the following items:

(1) Grain assumed to have been directly sprayed with the full application rate. No degradation occurs, it is not washed prior to eating, and 0.5 kg (about 1.1 pounds) is eaten. Preharvest waiting periods specified by the labels are assumed to be disregarded.

(2) A fish taken from a body of water 2-feet deep, receiving drift at 500 feet downwind. No degradation occurs, and 0.5 kg of fish is eaten.

(3) Jackrabbit, quail, or beef taken from the sprayed area. Ten percent of the insecticide dose received by the animal (as estimated in the wildlife exposure analysis) is assumed to be retained by the meat. Degradation or excretion have been assumed not to occur, and 0.5 kg is eaten.

(4) Water taken from a source 2-feet deep that has received insecticide from drift. Degradation and adsorption to sediments has not occurred yet. One liter is drunk.

Maximum total exposure to an individual was assumed to consist of dermal and inhalation doses, plus oral doses from eating grain and meat with the highest concentration and by drinking 1.0 liter of water containing insecticide.

Accidental doses were calculated for members of the public for the following cases:

(1) Direct spraying of a child with the full application rate. The child is assumed to weigh 20 kg (about 44 pounds), and 40 percent of body surface is not covered by clothing.

(2) Direct spraying of an unregistered crop (leafy vegetable) with the full application rate. It is assumed that no

degradation occurs, it is not washed prior to eating, and 0.5 kg (about 1.1 pounds) is eaten.

(3) Drinking water from a reservoir directly sprayed with the chemical. It is assumed to be 16 acres in area and average 8 feet deep.

(4) Drinking water from a reservoir after jettison into it of a full 200-gallon aircraft load of insecticide.

(5) Drinking water from a reservoir after a large thunderstorm washes insecticide into it from the surrounding area.

To determine the risks of cancer from exposure to the three chemicals, the linear cancer model was used, with the estimated total lifetime dose expressed in terms of an average daily dose over a 70-year lifetime.

It is presumed, based on historical data, that the chemical is sprayed only once in each control project (although multiple applications for cropland protection may occur on a few areas) and that such a project could be conducted in the same area every 7 years. Thus, over a period of 70 years, an individual could be exposed 10 times from projects. Insecticide degradation is assumed to be exponential, with a half-life representing the high end of the observed range.

Risk Analysis

To make judgments about the relative safety of the chemicals in an actual control project, the doses estimated in the exposure analysis are compared with the toxicity reference levels established for each chemical in the hazard analysis. The NOEL's, ADI's, and LD_{50}'s are compared with the amounts expected in various components of the environment.

For wildlife and aquatic risks, the criteria used by EPA in the ecological risk assessment (U.S. EPA, 1986a) shown in table 4-2 are used here to form judgments about the absolute risk to the organisms and the relative risks among chemicals. The EPA criteria call for comparison of an estimated environmental concentration (EEC) with a laboratory determined LD_{50} or LC_{50} for the most closely related laboratory test species.

Where the EEC exceeds one-fifth of the LD_{50} or LC_{50}, EPA deems it a significant risk that may be mitigated by restricting the use of the pesticide. EPA judges EEC's that exceed the LD_{50} or LC_{50} as unacceptable risk levels. In this risk analysis, an organism's total estimated dose (rather than the EEC) is compared with the laboratory value because the dose actually received by the animal determines the possible toxic effects.

Table 4-2--Regulatory risk criteria

	Presumption of no risk	Presumption of risk that may be mitigated by restricted use[1]	Presumption of unacceptable risk: Non-endangered species	Presumption of unacceptable risk: Endangered species[2]
I. Acute toxicity	Mammals EEC < 1/5 LC_{50} mg/kg/day < 1/5 LD_{50} LD50 > 50 mg/kg[3]	EEC $\geq$ 1/5 LC_{50} mg/kg/day > 1/5 LD_{50} LD_{50} $\leq$ 50 mg/kg[3]	EEC $\geq$ LC_{50}	EEC $\geq$ 1/10 LC_{50} or EEC $\geq$ 1/5 LC_{10}
	Bird EEC < 1/5 LC_{50} LD_{50} > 50 mg/kg[3]	1/5 LC_{50} $\leq$ EEC < LC_{50} LD_{50} $\leq$ 50 mg/kg[3]	EEC $\geq$ LC_{50}	EEC $\geq$ 1/10 LC_{50} or EC $\geq$ 1/5 LC_{10}
	Aquatic organisms EEC < 1/10 LC_{50}	1/10 LC_{50} $\leq$ EEC < 1/2 LC_{50} EEC $\geq$ 1/10 LC_{50}	EEC $\geq$ 1/2 LC_{50}	EEC > 1/20 LC_{50} or EEC > 1/10 LC_{10}
II. Chronic toxicity	EEC < Chronic no Effect level	N/A	EEC $\geq$ Chronic effect levels including reproductive effects	EEC $\geq$ Chronic effect levels including reproductive effects; also any adverse habitat modification

1/Restricted use is a classification of a pesticide whereby its use is limited to applicators who have been certified through EPA-approved training programs.
2/Interagency agreement between EPA/OPP, U.S. Department of Interior, Office of Endangered Species, and U.S. Department of Commerce, National Marine Fisheries Service, 1980.
3/For granular products only.

Sources: Part 162 - Regulations for the Enforcement of the FIFRA (FR 40 (129): 28260-28265; 28281-28284; Thursday, July 3, 1975). Proposed Change in Section 3 Regulations - Restricted Use Criteria (See Attachment B). Parts 154, 162 and 172 Special Reviews of Pesticides; Criteria and Procedures: Final Rule (40 CFR (229): 49007; 40016; Wednesday, November 27, 1985).

In terms of estimating the risks to human health, it must be emphasized that using the exposure comparisons with ADI's and NOEL's is an extremely conservative approach. Possible doses from spraying would be infrequent and short duration, yet the ADI's are estimated doses that are considered safe even if received every day for a lifetime. As another means of addressing risk, margins of safety are presented as a ratio of the lowest NOEL and estimated exposures for humans.

Because tests for cancer (called oncogenicity tests) with all three chemicals or their metabolite or conversion products were inconclusive, a cancer risk analysis is done to provide the public and the decisionmaker with an estimate for this nonthreshold response. These estimates can then be compared to commonly known health risks.

WILDLIFE

Impacts of Chemical Grasshopper Control Methods

This section presents the results of the risk assessment conducted to assess the potential effects of the alternative grasshopper control chemicals on terrestrial wildlife. The first part of this section, the wildlife hazard analysis, summarizes the findings of laboratory and field studies that indicate the alternative chemicals' toxicity to wildlife. Full details of those studies are given in appendix A. The second part gives the results of the wildlife exposure analysis. The detailed methods of the wildlife exposure analysis, outlined previously in this chapter, are given in appendix B. The third part of this section presents the wildlife risk analysis for each chemical.

The potential impacts on wildlife of chemicals used in grasshopper control may be direct or indirect. The chemicals may cause mortality or seriously harm a number of individual animals because of their inherent toxicity, or they may indirectly affect local populations of wildlife by causing behavioral abnormalities that reduce their reproductive success or affect their food supply of insects. For example, local grasshopper mouse populations were reported to increase with grasshopper numbers and experience gradual declines after control treatments (Lavigne and Pfadt, 1966). Based on the results of the exposure and hazard analyses, overall wildlife populations should not be adversely affected, although local populations may be indirectly affected. Site-specific environmental assessments will address impacts of a proposed treatment on an unstable or limited range wildlife population.

Hazard Analysis of Chemical Controls

Malathion ULV Spray. The toxic effects of malathion on wildlife vary considerably among species. Malathion is moderately toxic to mammals and moderately to slightly toxic to birds.

The mammalian oral LD_{50} ranges from 53 mg/kg for rabbits to 775 mg/kg for mice. The LD_{50} for birds ranges from 150 to 850 mg/kg for chickens (U.S. EPA, 1975) to 1,485 mg/kg for mallards (Hudson et al., 1984). These dose levels are not likely to be reached in a grasshopper control spraying.

Field studies (Henderson, 1967; McEwen et al., 1972; Sinclair, 1968; U.S. DOI, 1963) have shown no significant impacts to wildlife in areas treated with malathion at application rates similar to those used in grasshopper control. Malathion has been shown to reduce brain cholinesterase (ChE) (an enzyme important in nerve cell transmissions) levels in birds (Dobroski and Lambert, 1984); however, it is not likely that the amount of malathion used in grasshopper control would have long-term or severe toxic effects on birds in control areas. Short-term depressed ChE levels were observed in turkeys that were held in cages in an area treated with malathion at 0.58 lb a.i./acre, which is the prescribed application rate for the grasshopper program (USDA, 1985). Another study with ULV sprays at 1 to 10 times the normal application rate resulted in no ChE effects in bobwhite quail (Joseph et al., 1972).

Malathion is the most toxic to honey bees of the three chemical insecticides and can cause severe bee losses if sprayed in areas where they are foraging. The honey bee LD_{50} is 0.709 ug (microgram) per bee (Atkins et al., 1973). Bees can be killed by direct contact with sprayed surfaces or by consuming pollen that has malathion residues (Dobroski and Lambert, 1984). Any bees in a grasshopper control area during or immediately after a malathion spraying are likely to be killed.

Carbaryl Spray. Carbaryl's toxicity to wildlife also varies among species. Carbaryl is moderately toxic to mammals and slightly toxic to birds. The acute oral LD_{50} of carbaryl ranges from 150 mg/kg to 710 mg/kg for mammals, and from 780 mg/kg to more than 2,500 mg/kg for birds (NLM, 1986; Hudson et al., 1984; Ghassemi et al., 1981). These levels are not likely to be reached in a grasshopper control spraying with carbaryl at 0.5 lb/acre.

Field studies indicate that significant effects on mammals are unlikely as a result of grasshopper control with carbaryl. No adverse effects were reported on small mammals or deer in an area treated at 1.25 lb a.i./acre of carbaryl (Connor, 1960). At higher application rates (2 lb/acre and 4.46 lb/acre), decreases were seen in populations of moles and rodents (Denisova, 1973). These rates are 2-1/2 to 4 times higher than the 0.5 lb a.i./acre (8 oz a.i./acre) prescribed for grasshopper treatment.

It is not possible to accurately predict the degree of ChE inhibition likely to occur in birds or the subsequent effects

on the birds' behavior from a given grasshopper control application of carbaryl (0.5 lb/acre), although a number of studies have reported no adverse effects on bird populations in areas treated with carbaryl. The minimum application rate leading to doses causing depressed ChE levels in birds is not yet known, but it appears to be at a rate between 0.69 and 1.00 lb/acre. Zinkl et al. (1977) reported ChE inhibition in birds in areas treated with at least 1 lb/acre of carbaryl. However, at rates of 0.31 lb/acre and 0.69 lb/acre, no ChE decrease was observed (Gramlich, 1979).

One study has reported significant declines in bird populations in an area treated with carbaryl at 1 lb per acre (Moulding, 1972). This decline may have been a result of opportunistic feeding outside the area caused by a decrease in the insect population, reduced reproductive success, or a shift in nest-site loyalty to avoid the treated area. Doane and Schaefer (1971), in conjunction with removal of gypsy moth larvae with carbaryl treatments, suggested that the reduction in insect populations may disrupt the avian food chain in a sprayed area and cause displacement and lowered survival of avian species.

Studies indicate the possibility that the use of carbaryl may cause a significant reduction in the reproductive success of some avian species, for example, quail and pheasant. Although egg viability for quail was not affected in studies with oral treatment levels of 20, 40, and 400 ppm carbaryl, observed behavior modifications were suggested to possibly disrupt pair formation in the field, thus jeopardizing reproductive success (DeRosa et al., 1976). (The exposure analysis of this EIS estimated levels of carbaryl on avian food items to range from 88 to 442 ppm based on uniform surface contamination and a 0.5 lb a.i./acre application rate.) Other studies showed decreased chick survival and body weights in pheasant and quail caused by various exposure levels to carbaryl (DeWitt and Menzie, 1961; Bursian and Edens, 1977).

Carbaryl is also highly toxic to honey bees. The LD_{50} is 1.34 ug/bee for carbaryl dust and 1.02 ug/bee for Sevin 4-Oil (Atkins et al., 1973). Field studies indicate that bees may be killed by direct contact with treated surfaces. Young and reproductive members of a hive may be killed by eating contaminated pollen that has been brought back to the hive by worker bees (Dobroski, 1985). Adverse impacts to bees may be avoided if the colonies are moved temporarily out of the area to be sprayed or if alternate pollen sources such as corn pollen are made available (Dobroski, 1985).

The carbaryl formulation Sevin XLR Plus contains a small amount (about 0.1 percent) of formaldehyde as a preservative. EPA has reviewed data on the toxic properties of formaldehyde

and considered possible ecological effects (U.S. EPA, 1986d). EPA concluded that the "use of formulations containing less than one percent formaldehyde and paraformaldehyde are not expected to pose a risk to fish and wildlife species from the formaldehyde constituent." Consequently, the toxicity of formaldehyde to wildlife will not be considered further here. Toxicity of formaldehyde to humans is discussed in subsequent sections of this chapter and in appendix A.

Diesel and Petroleum Oils. The use of Sevin 4-Oil (49 percent carbaryl by weight, 46.3 percent petroleum oils by weight) diluted 4 to 1 by volume with diesel oil, as suggested for more efficient air application and longer residual insect control, would result in the dispersion of a low dosage of petroleum oils into the environment. The principal hazards associated with application of petroleum oils include reduced reproductive success in birds from oil on the eggs and sublethal effects such as diarrhea on small mammals because of contaminated forage.

The acute oral LD_{50} of diesel oil for mallard ducks over 1 year old is greater than 20 mL/kg (16,400 mg/kg) (Tucker and Crabtree, 1970), and the authors note that 20 mL/kg is far higher than any mallard is likely to come into contact with in normal pesticide applications. There are 337.4 mL of diesel plus petroleum oil sprayed with each 0.5 lb carbaryl per acre in grasshopper control. However, traces of oil on incubating eggs substantially decreases hatchability (Hartung, 1965; Kopischke, 1972). An oral LD_{50} of 9.0 mL/kg (7,380 mg/kg) diesel oil was found for rats (American Petroleum Institute, 1982). Acute toxicity studies of diesel fuel showed extreme skin irritation in rabbits but no eye irritation, and a skin sensitization test was negative using guinea pigs (American Petroleum Institute, 1982). Guinea pigs showed initial aversion to but no ill effects after 3 days of confinement on water treated with 400 and 800 mg/L (ppm) of aromatic hydrocarbons (Bruns et al., 1955).

Acephate Spray. Acephate is slightly toxic to mammals and moderately toxic to birds. The oral LD_{50} in rats is 866 mg/kg (U.S. EPA, 1984b). The oral LD_{50} for mallards is 234 mg/kg (Hudson et al., 1984). EPA (1985) requires acephate labels to warn of the product's toxicity to birds.

Brain cholinesterase depression has been reported for some small mammals and birds at acephate application rates of 0.094 lb a.i./acre. Generally, cholinesterase levels return to normal within a few days to several weeks after exposure to acephate (Lambert, 1985). The threshold level causing ChE depression varies considerably from species to species and between individuals of a species and cannot be predicted with precision for a given acephate application. Brain ChE

depressions of less than 25 percent probably would not have significant long-term effects on individual birds or bird populations. Depressions of greater than 50 percent may be fatal. Lower-level inhibition may produce behavioral changes that could affect survival or reproductive capability in individual animals. It is not likely that ChE inhibition would reach or exceed the 50-percent level in grasshopper control spraying of acephate at 0.094 lb/acre.

A significant decline in red-eyed vireos was noted following treatment of a forested plot in New York with 0.5 lb a.i./acre acephate, which is above the 0.094 lb a.i./acre application rate proposed for grasshopper control. Whether the decline was caused directly by acephate or by a reduction in the bird's insect food supply was not determined (Bart, 1979). However, the decreased singing activity in the crested flycatcher and the movement of two vireo species from an area sprayed with acephate was attributed to a reduced arthropod food supply (LOTEL, 1975).

Acephate is highly toxic to honey bees (Apis mellifera). The LD_{50} is 1.20 ug/bee (Atkins et al., 1973). Field studies indicate that bees can be adversely affected, but effects may be temporary. Damage can be lessened if sources of pollen and nectar are available outside the treatment area. Any bees foraging in a grasshopper control area during or immediately after an acephate spraying are likely to be killed.

Methamidophos. A small percent of acephate (2.5 to 10 percent in rats) may be metabolized in mammals and birds to methamidophos, a more toxic compound also registered and used as a pesticide. A larger percent (10 to 29 percent) of acephate may degrade rapidly to methamidophos on environmental and body surfaces and in water. Methamidophos is 10 to 70 times more toxic to wildlife than acephate (Lambert, 1985).

EPA (1982c) describes methamidophos as very highly toxic to birds via acute oral dosing (bobwhite LD_{50} = 8 mg/kg) and dietary exposures (bobwhite LC_{50} = 42 ppm). It is highly toxic to mammals via acute oral dosing (rat LD_{50} = 13 mg/kg, mouse LD_{50} = 14 mg/kg) although only slightly toxic in mammalian diets (rat LC_{50} = 894 ppm). At the application rate for acephate used by APHIS in grasshopper control, dietary levels of methamidophos after spraying may range from 5 to 20 ppm on insects, grasshoppers, and seeds, assuming 10 to 29 percent of acephate degrades to methamidophos. These levels may present some risk of ChE depression to birds; there is lower risk to mammals.

Table 4-3--Estimated malathion doses to representative wildlife species (milligrams)

Species	Direct dermal dose	Oral dose via grooming	Inhalation dose	Dose from food	Total dose	Dose in mg/kg
Lark Bunting	2.14×10^{-2}	0.68	1.00×10^{-5}	2.02	2.71	82.20
Sage Grouse	0.41	2.02	1.89×10^{-4}	17.41	19.84	13.23
Bobwhite Quail	8.56×10^{-2}	1.03	3.54×10^{-5}	8.54	9.66	56.82
American Kestrel	6.76×10^{-2}	0.95	2.79×10^{-5}	5.31	6.33	50.64
Grasshopper Mouse	3.03×10^{-2}	0.74	1.18×10^{-5}	1.67	2.44	76.27
Blacktail Jackrabbit	0.84	2.53	4.11×10^{-4}	31.13	34.50	12.67
Pronghorn	5.70	6.73	3.96×10^{-3}	286.71	299.14	6.49
Beef Cow	26.47	15.49	2.46×10^{-2}	1168.25	1210.24	2.67
Coyote	2.73	4.57	1.65×10^{-3}	4.10	54.15	3.49
Horned Lizard	4.90×10^{-2}	0	1.63×10^{-6}	1.84	1.89	75.70
Yellow-Bellied Racer	0.27	0	1.63×10^{-6}	1.95	3.55	8.99
Rocky Mountain Toad	0.24	0	3.41×10^{-6}	1.09	1.34	60.76

Exposure Analysis of Chemical Controls

The detailed methodology and calculations used to estimate the exposures to wildlife are presented in appendix B. The results of the wildlife exposure analysis for each alternative insecticide, for diesel and petroleum oils, and for methamidophos are given in tables 4-3 through 4-7.

It should be kept in mind in examining the exposure analysis results that the exposures of representative wildlife species derived in this analysis are conservative estimates because of the assumptions used in calculating them. The doses resulting from the estimated exposures are intended to reflect the highest doses that could be experienced by an individual organism under the actual conditions of grasshopper control spraying.

Table 4-4--Estimated carbaryl doses to wildlife (milligrams)

Species	Direct dermal dose	Oral dose via grooming	Inhalation dose	Dose from food	Total dose	Dose in mg/kg
Lark Bunting	2.63×10^{-2}	0.58	8.63×10^{-6}	1.74	2.35	71.10
Sage Grouse	0.50	1.74	1.63×10^{-4}	15.01	17.26	11.50
Bobwhite Quail	0.11	0.89	3.05×10^{-5}	7.36	8.36	49.17
American Kestrel	8.33×10^{-2}	0.82	2.41×10^{-5}	4.58	5.48	43.85
Grasshopper Mouse	3.73×10^{-2}	0.63	1.01×10^{-5}	1.44	2.12	66.10
Blacktail Jackrabbit	1.04	2.18	3.55×10^{-4}	26.84	30.05	11.04
Pronghorn	7.01	5.80	3.41×10^{-3}	247.16	259.98	5.64
Beef Cow	32.60	13.36	2.12×10^{-2}	1007.11	1053.09	2.32
Coyote	3.37	3.94	1.43×10^{-3}	3.53	47.89	3.09
Horned Lizard	6.03×10^{-2}	0	1.40×10^{-6}	1.59	1.65	65.98
Yellow-Bellied Racer	0.33	0	1.40×10^{-6}	1.68	3.25	8.23
Rocky Mountain Toad	0.30	0	2.94×10^{-6}	0.94	1.24	56.46

All representative species are assumed to receive doses through all three principal exposure routes: oral, dermal, and inhalation. All representative species and their food items are assumed to receive surface contamination on their total surface area. Prey items are assumed to have a total day's body burden of chemical to contribute to a predator's oral exposure. There is no loss of chemical assumed to occur from an animal's body to the environment either by rubbing off from the fur or feathers or through normal chemical breakdown processes. Losses from the fur or feathers by grooming are assumed to constitute oral doses for mammals and birds. Dermal penetration is assumed to occur within the first day of spraying at the penetration rate determined in the laboratory over a number of days. Thus the analysis is structured to anticipate the most hazardous outcome of a spraying operation in terms of toxic consequences to an individual animal.

Table 4-5--Estimated diesel/petroleum oil doses to wildlife (microliters)

Species	Direct dermal dose	Oral dose via grooming	Inhalation dose	Dose from food	Total dose	Dose in ul/kg
Lark Bunting	.172	1.52	3.45×10^{-4}	4.54	6.23	188.9
Sage Grouse	3.27	4.54	6.52×10^{-3}	39.2	47.0	31.3
Bobwhite Quail	.687	2.32	1.22×10^{-3}	19.2	22.2	130.8
American Kestrel	.543	2.13	9.62×10^{-4}	12.0	14.7	117.2
Grasshopper Mouse	.243	1.65	4.06×10^{-4}	7.1	9.0	281.6
Blacktail Jackrabbit	6.76	5.68	1.42×10^{-2}	40.0	52.4	19.3
Pronghorn	45.7	15.1	.136	368	429	9.31
Beef Cow	212.5	34.8	.850	1,529	1,777	3.92
Coyote	21.9	10.3	5.70×10^{-2}	109.5	141.8	9.15
Horned Lizard	0.39	0	5.61×10^{-5}	4.15	4.54	181.7
Yellow-Bellied Racer	2.15	0	5.61×10^{-5}	8.82	10.97	27.76
Rocky Mountain Toad	1.95	0	1.18×10^{-4}	2.48	4.44	201.7

The results of the exposure and risk analyses cannot and should not be extrapolated directly to predict impacts at the population level. Most animals should receive lower doses than those estimated here. A considerable segment of any population in a sprayed area should receive relatively low or negligible doses. Many burrowing mammals--prairie dogs and moles, for example--should receive relatively low doses. Small mammals and nesting birds and their eggs (protected from direct spray by vegetation) should receive lower doses than those estimated here.

Larger animals, such as the coyote and pronghorn, which are more likely to receive direct exposures, have proportionately lower doses on a body weight basis because of their lower ratio of body surface to body weight. In addition, should these large animals experience toxic symptoms such as cholinesterase depression as a result of a spraying, they are far

Table 4-6--Estimated acephate doses to wildlife (milligrams)

Species	Direct dermal dose	Oral dose via grooming	Inhalation dose	Dose from food	Total dose	Dose in mg/kg
Lark Bunting	4.95×10^{-3}	0.11	1.62×10^{-6}	0.33	0.44	13.37
Sage Grouse	9.44×10^{-2}	0.33	3.06×10^{-5}	2.82	3.24	2.16
Bobwhite Quail	1.98×10^{-2}	0.17	5.73×10^{-6}	1.38	1.57	9.24
American Kestrel	1.57×10^{-2}	0.15	4.52×10^{-6}	0.86	1.03	8.25
Grasshopper Mouse	7.01×10^{-3}	0.12	1.91	0.27	0.40	12.43
Blacktail Jackrabbit	0.20	0.41	6.67×10^{-5}	5.05	5.65	2.08
Pronghorn	1.32	1.09	6.41×10^{-4}	46.47	49.99	1.06
Beef Cow	6.13	2.51	4.00×10^{-3}	189.34	197.98	0.44
Coyote	0.63	0.74	2.68×10^{-4}	0.66	9.00	0.58
Horned Lizard	1.13×10^{-2}	0	2.64×10^{-7}	0.30	0.31	12.41
Yellow-Bellied Racer	5.20×10^{-2}	0	2.64×10^{-7}	0.32	0.61	1.55
Rocky Mountain Toad	5.63×10^{-2}	0	5.53×10^{-7}	0.18	0.23	10.61

less likely to be as vulnerable to predation as small mammals and birds.

Tables 4-3 through 4-7 list (1) the doses of the grasshopper control chemicals, diesel/petroleum oils, and methamidophos estimated to be received by each representative species through the three principal exposure routes; (2) the total dose as the sum for all exposure routes; and (3) the dose per body weight for each animal. Doses for the control chemicals and methamidophos are in milligrams. Doses for diesel and petroleum oil are in microliters.

In general, total doses are higher for the larger birds and mammals, but doses on a body weight basis are higher for smaller birds and mammals. These latter would be more susceptible to the chemical's toxic effects. Malathion doses (table 4-3) range from less than 3 mg/kg for the beef cow to

Table 4-7--Estimated methamidophos doses to wildlife (milligrams)

Species	Direct dermal dose	Oral dose via grooming	Inhalation dose	Dose from food	Total dose	Dose in mg/kg
Lark Bunting	1.1×10^{-3}	.024	0	.079	.10	3.1
Sage Grouse	.025	.087	0	.82	.93	.62
Bobwhite Quail	4.8×10^{-3}	.041	0	.34	.38	2.3
American Kestrel	3.7×10^{-3}	.037	0	.25	.29	2.3
Grasshopper Mouse	1.4×10^{-3}	.025	0	.060	.086	2.7
Blacktail Jackrabbit	.052	.11	0	.50	.67	.24
Pronghorn	.37	.31	0	4.6	5.3	.12
Beef Cow	1.8	.72	0	18.9	21.0	.05
Coyote	.18	.20	0	2.4	2.7	.18
Horned Lizard	2.8×10^{-3}	0	0	.087	.090	3.6
Yellow-Bellied Racer	0.17	0	0	.17	.19	.48
Rocky Mountain Toad	.013	0	0	.051	.065	2.9

82 mg/kg for the lark bunting. Carbaryl doses (table 4-4) range from 2.3 mg/kg for the cow to 71 mg/kg for the lark bunting. Diesel/petroleum oil doses (table 4-5) range from 5.3 ul/kg for the coyote to 114.4 ul/kg for the Rocky Mountain toad. Acephate doses (table 4-6) are the lowest of the chemicals, ranging from 0.44 mg/kg for the cow to less than 14 mg/kg for the lark bunting. Doses of the acephate environmental breakdown product, methamidophos (table 4-7), range from .19 mg/kg for the coyote to 3.1 mg/kg for the lark bunting and 3.6 mg/kg for the horned lizard.

Risk Analysis of Chemical Controls

The risks to each representative wildlife organism can be inferred by an examination of tables 4-8 through 4-12, which

list total doses in mg/kg versus laboratory-determined reference doses for the most closely related laboratory test species and the EPA risk level of one-fifth of the LD_{50}'s.

There is a possibility of indirect effects on local wildlife populations, particularly insectivorous birds that depend on a readily available supply of insects, including grasshoppers, for their own food supply and for their young. To the extent that grasshopper spraying causes a severe reduction in target and nontarget insects, it is likely to jeopardize the survival of local populations of these wildlife species. Because of the territoriality of bird and mammal species and the inherent carrying capacity of given habitat types in which these species have evolved, it is not likely that these species would have the same success in foraging or rearing offspring by displacing their foraging activities to nearby unsprayed areas. The displacement of these birds and their reduced survival may in turn affect predatory species, such as peregrines or other raptors, that depend on them as a food source.

A number of factors would tend to mitigate serious population losses of insectivorous species and their predators. First, grasshopper control is conducted only where grasshopper density has become relatively high and where the grassland habitat may be destroyed by them. In these instances, protection of the grassland habitat may be as necessary to the birds' survival as a continued supply of insects. In addition, the efficacy of the insecticides seldom reaches 100 percent so that at least some fraction of the grasshopper and nontarget insect population should remain for grasshopper predators to feed on.

Second, grasshopper and other rangeland insect populations are by nature extremely variable in size. Birds evolved to feed on them must be adapted to this variability and, at least on a species population basis, must have been able to survive and reproduce despite this unpredictability. In any given treatment season, only a fraction (less than 1 percent) of the total rangeland in a region is likely to be sprayed for grasshopper control. It is reasonable to conclude that the treated area would therefore constitute only a fraction of the total range of the species population and that lowered survival and lowered reproductive success in that area for that species would not constitute a significant threat to the species overall.

Malathion. Estimated wildlife doses of malathion listed in table 4-8 exceed the EPA risk criterion (one-fifth of LD_{50}) for the lark bunting, bobwhite quail, American kestrel, and black-tailed jackrabbit. Doses to the horned lizard and Rocky Mountain toad approach the criterion level. However, no dose approaches or exceeds the reference species LD_{50}. These results indicate that wildlife may be at some risk of fatality

Table 4-8--Risk comparison of estimated wildlife doses of malathion with toxicity reference levels

Representative species	Estimated dose (mg/kg)	Reference doses 1/5 LD_{50}	LD_{50}	Reference species
Birds				
Lark Bunting	82.2	80.6	403	Horned Lark
Sage Grouse	13.2	30	150	Chicken
Bobwhite Quail	56.8	30	150	Chicken
American Kestrel	50.6	30	150	Chicken
Mammals				
Grasshopper Mouse	76.3	115	775	Mouse
Blacktailed Jackrabbit	12.7	10.6	53	Rabbit
Pronghorn	6.5	16	80	Dairy Calves
Beef Cow	2.7	16	80	Dairy Calves
Coyote	3.5	10.6	53	Rabbit
Reptiles				
Horned Lizard	75.7	84	420	Toad LC_{50}
Yellow-Bellied Racer	9.0	84	420	Toad LC_{50}
Amphibian				
Rocky Mountain Toad	60.8	84	420	Toad LC_{50}

or behavioral alterations that make them more susceptible to predation resulting from ChE level changes in malathion spraying for grasshopper control. However, most individual animals would not be seriously affected.

Carbaryl. The carbaryl dose to the grasshopper mouse exceeds the criterion for risk. All other wildlife doses listed in table 4-9 are less than one-tenth of the median lethal dose for most closely related test species. Therefore, carbaryl poses a lower risk to wildlife than malathion, with fewer fatalities likely to occur and a lower risk of behavioral anomalies caused by cholinesterase depression.

Table 4-9--Risk comparison of estimated wildlife doses of carbaryl with toxicity reference levels

Representative species	Estimated dose (mg/kg)	Reference doses 1/5 LD_{50}	LD_{50}	Reference species
Birds				
Lark Bunting	71.1	156	780	Sharp-Tailed Grouse
Sage Grouse	11.5	156	780	Sharp-Tailed Grouse
Bobwhite Quail	49.2	458	2290	Japanese Quail
American Kestrel	43.9	156	780	Sharp-Tailed Grouse
Mammals				
Grasshopper Mouse	66.1	55	275	Mouse
Blacktailed Jackrabbit	11.0	142	710	Rabbit
Pronghorn	5.6	40	200	Mule Deer
Beef Cow	2.3	40	200	Mule Deer
Coyote	3.1	30	150	Cat
Reptiles				
Horned Lizard	66.0	138	690	Lake Trout
Yellow-Bellied Racer	8.2	138	690	Lake Trout
Amphibian				
Rocky Mountain Toad	56.5	138	690	Lake Trout

Diesel and petroleum oils. Doses of diesel oil and petroleum oil resulting from the application of carbaryl in Sevin 4-Oil diluted with diesel oil are listed in table 4-10. The doses are in all cases far below the EPA risk criteria of one-fifth of the LD_{50} based on the LD_{50}'s for the mallard and rat. Therefore, the use of these oils does not appear to pose a significant risk to wildlife. (See the discussion on risks to bird eggs below.)

Acephate. Acephate doses to wildlife listed in table 4-11 are all below the 1/5 LD_{50} risk criterion, most of them far below that level. Acephate poses the lowest risk to wildlife of the

Table 4-10--Risk comparison of estimated wildlife doses of diesel/petroleum oil with toxicity reference levels

Representative species	Estimated dose[1/] (ul/kg)	Reference doses 1/5 LD_{50}	LD_{50}	Reference species
Birds				
Lark Bunting	188.9	4,000	20,000	Mallard
Sage Grouse	31.3	4,000	20,000	Mallard
Bobwhite Quail	130.8	4,000	20,000	Mallard
American Kestrel	117.2	4,000	20,000	Mallard
Mammals				
Grasshopper Mouse	281.6	1,472	7,380	Rat
Blacktailed Jackrabbit	19.3	1,472	7,380	Rat
Pronghorn	9.31	1,472	7,380	Rat
Beef Cow	3.92	1,472	7,380	Rat
Coyote	9.15	1,472	7,380	Rat
Reptiles				
Horned Lizard	181.7	Not available		--
Yellow-Bellied Racer	27.8	Not available		--
Amphibian				
Rocky Mountain Toad	201.7	Not available		--

1/ 1 uL = 1/1000 mL = .82 mg diesel oil.

three alternative chemicals at the recommended application rate.

Methamidophos doses as listed in table 4-12 exceed the EPA criteria level for the lark bunting, bobwhite quail, and American kestrel. All other estimated methamidophos doses are below the EPA 1/5 LD_{50} levels. Smaller birds and mammals, particularly those that feed on grasshoppers, may be at risk from methamidophos doses because of the rapid degradation of acephate into this more toxic compound. These risks would include reduced cholinesterase levels and related behavioral anomalies and some risk of fatality, as described for malathion.

Table 4-11--Risk comparison of estimated wildlife doses of acephate with toxicity reference levels

Representative species	Estimated dose (mg/kg)	Reference doses 1/5 LD_{50}	LD_{50}	Reference species
Birds				
Lark Bunting	13.4	21.2	106	Dark-Eyed Junco
Sage Grouse	2.2	113.6	568	Chicken
Bobwhite Quail	9.2	113.6	568	Chicken
American Kestrel	11.4	21.2	106	Dark-Eyed Junco
Mammals				
Grasshopper Mouse	12.4	30	150	Mouse
Blacktailed Jackrabbit	2.1	106	530	Rabbit
Pronghorn	1.1	30	150	Mouse
Beef Cow	0.4	30	150	Mouse
Coyote	0.6	30	150	Mouse
Reptiles				
Horned Lizard	12.4	1286.6	6433	Green Frog
Yellow-Bellied Racer	1.5	1286.6	6433	Green Frog
Amphibian				
Rocky Mountain Toad	10.6	1286.6	6433	Green Frog

It should be noted that, using EPA (1982c) methodology for assessing risk to bobwhite quail, long-term dietary risk to young quail would not be considered a problem in APHIS control programs.

Risk of effects on bird eggs. Malathion in acetone killed 15 percent of the embryos when injected into hens' eggs at 25 mg/kg. Carbaryl injected into hens' eggs at 100 mg/kg killed 61 percent of the embryos. Diesel oil at 300 mg/kg was shown to virtually eliminate hatching. One microliter application of crude oil (lowest level tested) and No. 2 fuel oil reduced 96-hour survival and 30-day hatching success of mallard eggs from 20 to 38 percent. No comparable information is known about acephate.

Table 4-12--Risk comparison of estimated wildlife doses of methamidophos with toxicity reference levels

Representative species	Estimated dose (mg/kg)	Reference doses 1/5 LD_{50}	LD_{50}	Reference species
Birds				
Lark Bunting	3.1	1.6	8	Dark-eyed Junco
Sage Grouse	.62	5	25	Chicken
Bobwhite Quail	2.3	2.0	10.1	Bobwhite Quail
American Kestrel	2.3	1.6	8	Dark-eyed Junco
Mammals				
Grasshopper Mouse	2.7	2.8	14	Mouse
Blacktailed Jackrabbit	.24	2	10	Rabbit
Pronghorn	.12	1.5	7.5	Rat
Beef Cow	.05	1.5	7.5	Rat
Coyote	.18	1.5	7.5	Rat
Reptiles				
Horned Lizard	3.6	--	NA[1]	--
Yellow-Bellied Racer	.48	--	NA	--
Amphibian				
Rocky Mountain Toad	2.9	--	NA	--

[1]NA: not available

Assuming a bird egg weighs 38 grams, has a surface area of 113 cm^2, receives an exposure from direct spray of each chemical at the recommended application rate on half the surface area, and 100 percent is absorbed into the egg, the following doses would result: malathion, 9.7 mg/kg; carbaryl, 8.3 mg/kg; diesel/petroleum oil, 13.2 mg/kg; and acephate 1.6 mg/kg. The amount of diesel/petroleum oil on one-half the egg surface would be 0.47 microliters. (Details of calculations of oil on the egg surface are presented in appendix B.) These results indicate that there is some chance

of adverse effects on bird reproduction through direct toxicity to developing embryos in birds' eggs.

Carbaryl Bait. Some species of granivorous mammals and birds may consume wheat bran bait after it has been applied to grasshopper-infested areas. Carbaryl is moderately toxic to mammals; the lowest acute oral LD_{50} is 150 mg/kg. It is slightly toxic to birds; the lowest LD_{50} is 780 mg/kg. Table 4-13 lists the amount of bait that would have to be eaten by three wildlife species to exceed the risk criterion of one-fifth of the LD_{50} for carbaryl. The table also lists the ground surface area over which the animal would have to forage to obtain the bait to be eaten, assuming a uniform distribution of 10 pounds of bait per acre. Because the amount of bait required to be eaten is relatively low for each species, it is possible that wildlife species, particularly smaller birds and mammals, feeding on the bait would receive toxic doses and some fatalities might occur. There is a clear possibility of cholinesterase depression for any animals feeding on carbaryl bait.

Impacts of Multiple Chemical Applications

Rangeland areas adjacent to croplands may be treated with carbaryl or malathion more than once during a growing season to protect the croplands from migrating grasshoppers. The acephate label prohibits repeated applications on rangeland within the same season. Malathion and carbaryl retreatments may occur at 4-week intervals. In these instances, neither of the chemicals is likely to cause any greater adverse direct toxicity effects than those discussed above under individual treatments because the chemicals degrade rapidly and do not tend to bioaccumulate. Multiple treatments are not likely to have any added impact on bird reproduction resulting from direct toxicity to eggs because the time interval between sprayings would greatly limit the chances of an egg being sprayed more than once before hatching. Incubation periods range from 2 to 3 weeks for most species. For example, incubation periods for the western meadowlark are 13 to 15 days; for the horned lark, 11 days; for the mourning dove, 13 to 14 days; and for the bobwhite quail, 23 to 24 days (Harrison, 1975).

Multiple treatments would tend to increase the risks to survival of those local wildlife populations, particularly insectivorous birds, that depend on a relatively abundant insect food supply for their own food and to successfully reproduce. However, multiple treatments are most likely to occur on cropland border areas, which are much more limited in extent than the broader rangeland grasshopper control treatments. Therefore, the risks to any wildlife population from multiple applications would be much lower than that discussed

Table 4-13--Estimated doses of carbaryl bait to granivorous wildlife species

Species	Body weight(g)	Carbaryl risk level (mg/kg)1/	Toxicity reference species	Mg required to exceed risk level2/	Grams of bait eaten to exceed risk level	Square meters/square feet covered by risk level amount of bait3/
Lark Bunting	33	154	Sharp-Tailed Grouse	5.1	0.10	.09/.97
Bobwhite Quail	170	458	Japanese Quail	77.9	1.56	1.39/14.96
Grasshopper Mouse	32	55	Mouse	1.8	0.36	.32/3.44

1/1/5 LD_{50} for reference species.
2/Assumes 5 percent carbaryl bait.
3/Assumes 1.12 grams of bait per square meter at 10 lb bait/acre.

above for single broadscale treatments, even though risks to some individual breeding pairs may be greater.

Impacts of Biological Control Methods

Nosema has no known adverse effects on wildlife species. No toxic effects were observed in acute oral tests with mallards and pheasants at doses of 5×10^9 spores/bird (Hudson et al., 1984). In addition, honey bees are not susceptible to infection by Nosema (Menapace et al., 1978).

Potential Impacts on Endangered and Threatened Wildlife Species

APHIS is committed to ensuring that any alternative chosen under the grasshopper management program complies with the Endangered Species Act. The process of formal and informal consultation with the Fish and Wildlife Service is described in chapter 5 of this EIS. APHIS has prepared a Biological Assessment for the 17 western States and Alaska that analyzes the effects of the three proposed chemical insecticides on endangered and threatened wildlife. A 1-mile no-treatment zone will be established for all peregrine falcon nest sites. A 1-mile no-treatment zone will also be applied to bald eagle nesting sites. Additional protection measures for endangered and threatened species are proposed in the Biological Assessment and are subject to further modification in the Biological Opinion prepared by the Fish and Wildlife Service.

Site-specific environmental assessments will be prepared in cooperation with the Fish and Wildlife Service and State wildlife agencies and will address potential impacts on federally listed endangered and threatened species, candidate species, State-listed species, and limited range or unstable populations. Site-specific protection measures will be developed as needed.

A concern exists about the depression of brain cholinesterase in birds and small mammals at various dosage levels of chemical sprays (see appendix A). EPA lists acephate as a rangeland pesticide that may affect endangered avian species because of its effect on ChE (U.S. EPA, 1986b). The petroleum oil in Sevin 4-Oil (carbaryl) may cause reduced egg production and hatchability in avian species (U.S. DOE, 1983). The research to be conducted on the IPM demonstration sites (described in chapter 2) on these effects will be used to further refine APHIS operational procedures and protection measures.

Impacts of Grasshopper Control Alternatives

No Action

The no action alternative would not cause a decrease in the number of prey insects available to nesting birds, fish, and other insectivores. However, if grasshopper infestations are not controlled, virtually all grasses and forbs could be destroyed in an affected area and plant growth could be

retarded for several years. This would result in a localized disruption of habitat providing food and cover for wildlife species. Overall numbers of animals and diversity of species could be reduced by direct mortality, reduced reproductive success, and emigration from the area.

Chemical Control Alternative

The chemicals are slightly to moderately toxic to birds and mammals, and highly toxic to honey bees. Operational procedures (table 2-1) would mitigate adverse impacts to honey bees, but wild pollinators in the treatment area may be killed. Field studies indicate that there have been no significant direct toxic effects on wildlife in areas treated with chemicals at application rates similar to those proposed for the current program, although indirect effects caused by a loss in insect prey base to local populations have been seen. Based on the results of the risk assessment based on APHIS application rates, the chemicals ranked in order of increasing risk to wildlife are acephate, carbaryl bait, carbaryl spray, and malathion. Depression of ChE levels may occur in small mammals and birds. However, threshold rates and degree of inhibition caused are not yet known and could not be predicted in this analysis. Effects of ChE inhibition are not fully understood but could cause inability to gather food, escape predation, or care for young. Studies with higher application rates than those of the grasshopper program reported movement and displacement of avian species as a result of reduced insect populations needed for food.

Petroleum oils in Sevin 4-Oil with the diesel oil carrier may reduce egg production and hatchability in avian species. Some direct toxicity of the insecticides to eggs through absorption through the shells may occur. Toxicity would likely be highest with Sevin 4-Oil because of the combined toxicity of the insecticide and the oil carrier.

Direct dermal exposure is likely to occur more often in regions such as the short-grass prairie and Great Basin where grass and forb cover is sparse. Tall grasses would tend to intercept a large amount of spray. Indirect dermal exposure through contact with contaminated vegetation may be higher in the tallgrass region. Nevertheless, total dermal doses are likely to be lower there. Direct dosing of eggs is likely to be lower where vegetation is more dense.

In the more arid regions, animals adapted to the area are far less likely to receive doses from contaminated water. Many desert region species are adapted to filling their entire water requirement in their food items and to concentrate their urine to conserve water. Burrowing animals would be the least likely to receive direct dermal or inhalation doses; however, their

food supply (for example, grasses for prairie dogs) will be contaminated at some level as a result of spraying. The analysis shows that most pesticide received by nontarget species is through their food. Bait applications would limit the kinds of nontarget organisms thus affected because only one food source, the bait itself, is contaminated. However, granivorous birds and small mammals would be at risk at the current rate of carbaryl bait application.

While any of the above effects may affect individuals or local populations, overall species populations should not be adversely affected. Any local unstable or limited range species on a proposed treatment area would be addressed in site-specific environmental assessments.

IPM Alternative

Under this alternative, the impacts of chemical and biological controls as described in the previous sections would occur, although the use of chemicals would be less than under the chemical control alternative. Therefore, any chemical impacts would be proportionally lower. Nosema is highly specific to grasshoppers, and no adverse impacts to wildlife or honey bees would be expected from its use.

AQUATIC SPECIES

Impacts of Chemical Grasshopper Control Methods

This section presents the results of the risk assessment conducted to assess the potential effects of the alternative grasshopper control chemicals on aquatic organisms. The first part of this section, the aquatic hazard analysis, summarizes the findings of laboratory and field studies that indicate the toxicity of the insecticides to fish and other aquatic organisms. Details of those studies are given in appendix A. The second part gives the results of the aquatic organism exposure analysis. The detailed methods of the aquatic exposure analysis, outlined previously in this chapter, are given in appendix B. The third part of this section presents the risk analysis for each chemical to aquatic organisms.

Operational procedures call for a 500-foot buffer between treated areas and bodies of water supporting higher aquatic life. Thus, under normal operating conditions, the chemicals would reach water only through spray drift. There should be no long-term effects to any species of aquatic organism from using carbaryl, acephate, or malathion in grasshopper control operations. No fish or crayfish should be killed. Populations of aquatic insects could be reduced, particularly in streams, by malathion or carbaryl, but any effects should be temporary.

If carbaryl were directly sprayed onto a reservoir, or if severe storm runoff occurs after spraying, some aquatic insects

and invertebrates would be severely affected. In an accident where reservoirs are directly sprayed with malathion, or where 200 gallons of carbaryl or malathion spray mixtures are jettisoned into a reservoir, fish and other aquatic species would be severely affected. Aquatic invertebrates could experience population reductions in a stream receiving storm runoff after using malathion. However, these situations are unlikely and are not expected to occur. No adverse effects should result from diesel or petroleum oils under routine conditions, although fish kills and reductions in aquatic invertebrates would result if a load is jettisoned into a reservoir.

Hazard Analysis of Chemical Controls

Malathion ULV Spray. Malathion is moderately toxic to fish. The 96-hour LC_{50} is 200 ug/L for rainbow trout and 103 ug/L for bluegill. Species such as channel catfish, black bullhead, fathead minnow, and carp are much less sensitive (Johnson and Finley, 1980). Some aquatic arthropods are very sensitive to malathion. Population reductions of stoneflies and mayflies have been observed in the field following aerial applications of malathion. However, rapid recovery of insect populations is likely to occur (Dobroski and Lambert, 1984).

Carbaryl Spray. The 96-hour LC_{50} for the technical material is 2.1 mg/L for brook trout (Johnson and Finley, 1980). The technical material is more toxic than the commercial formulation, Sevin 4-Oil. The 96-hour LC_{50} for the 49-percent, oil dispersion formulation of carbaryl (Sevin 4-Oil) is 4.5 mg/L for brook trout. Acetylcholinesterase (AChE) depression has been observed at application rates of 1 lb/acre.

Aquatic insects, daphnids, and scuds are very sensitive to technical carbaryl. The Sevin 4-Oil formulation is slightly less toxic (Johnson and Finley, 1980). Mayflies and caddisfly populations do not suffer long-term effects, but populations of scuds may not recover for an extended period (Gibbs et al., 1984). Although surface waters contain higher concentrations of insecticide for several hours after Sevin 4-Oil application, residues are equally dispersed throughout the water column within 24 hours.

The carbaryl formulation Sevin XLR Plus contains a small amount (about 0.1 percent) of formaldehyde as a preservative. EPA has reviewed data on the toxic properties of formaldehyde and considered possible ecological effects (U.S. EPA, 1986d). EPA concluded that the "use of formulations containing less than one percent formaldehyde and paraformaldehyde are not expected to pose a risk to fish and wildlife species from the formaldehyde constituent." Consequently, the toxicity of formaldehyde to aquatic organisms will not be considered further here.

Carbaryl Bait. Carbaryl mixed with wheat bran, as well as the premixed Sevin bait, will be applied at a rate of 0.5 lb a.i./acre carbaryl. Carbaryl is listed as toxic to aquatic organisms and application over water bodies is prohibited. Although drift should not pose a problem with bait, uneaten bait could be broken down by rain, and carbaryl could be washed into nearby water bodies.

Diesel Oil and Petroleum Oils. The use of Sevin 4-Oil diluted up to 4 to 1 by volume with diesel oil for more efficient application and longer residual insect control would result in dispersion of a low dosage of petroleum oils into the environment. When pure fuel oil is applied directly to water bodies, a film forms on the surface. This oil can have toxic effects on some organisms (Larson et al., 1977). Oils may affect fish because of their toxic components, may coat gill epithelial surfaces, may elevate biological oxygen demand, and have adverse effects on food organisms (Morrow, 1974). EPA (1976) reports a 96-hour LC_{50} greater than 1.20 ppm as the acute toxicity of diesel fuel (No. 2 fuel oil) to fresh-water fish. Oils are also toxic to mosquito larvae and other aquatic invertebrates such as crayfish (McKee and Wolf, 1963). However, the dosage of fuel oil proposed to be applied for grasshopper control is much lower than the toxic levels, except in the case of an accidental spill or repeated applications.

Acephate Spray. Acephate is relatively nontoxic to fish, and lethal doses are far greater than could be expected to occur from normal grasshopper control operations (Schoettger and Mauck, 1976). The 96-hour LC_{50} for rainbow trout is 730 mg/L for the 75-percent soluble form of acephate.

Brain AChE may be depressed in some species of fish after exposure to acephate. A change in feeding habits also has been reported that indicated an overall increase in the prey volume taken per fish (Rabeni, 1978). However, a field study of warm-water fish in a pond treated at 0.5 lb acephate per acre reported no fish mortality or behavioral changes (LOTEL, 1975).

Amphibians (larval and adult) were not adversely affected in forests treated at 0.5 lb and 1 lb a.i./acre of acephate (Buckner and McLeod, 1975). Aquatic insects are more sensitive than fish to acephate. The 96-hour LC_{50} for the stoneflies of the genus *Skwala* is 12 mg/L (Johnson and Finley, 1980). Populations of aquatic insects were temporarily decreased in areas treated with 0.5 lb a.i./acre of acephate. Recovery occurred within 9 days for caddisflies and mayflies (Rabeni and Gibbs, 1979; LOTEL, 1975).

Exposure Analysis of Chemical Controls

Detailed information on the environmental fate properties of the chemicals is given in appendix B.

Malathion degrades rapidly by hydrolysis and microbial breakdown. The half-life is 36 hours at pH 8 (Wolfe et al., 1977). The potential for bioaccumulation is low and the chemical is quickly excreted from fish (Dobroski and Lambert, 1984). Field monitoring results of the 1984 grasshopper spray program by APHIS Plant Protection and Quarantine in Idaho indicate malathion residues in water within or adjacent to the treatment area ranged from less than 0.10 ppb to 20.00 ppb immediately after spraying (Ford, 1984).

Carbaryl degrades rapidly in water in 1 to 5 days. The bioaccumulation potential is low and the chemical is quickly excreted by fish (Dobroski, 1985).

Acephate degrades slowly in water. The half-life at pH 7 and water temperature of 70 °F is approximately 47 days (Etter and Tissier, 1973). Bioaccumultation potential is very low (Larson, 1975).

Detailed calculations of drift and runoff used to estimate amounts of each insecticide likely to reach water bodies are given in appendix B.

The expected pesticide concentrations in water under the routine scenarios are listed in table 4-14. These are initial concentrations. Concentrations in the stream would not remain long within a given stretch of stream because of dilution and mixing with water from upstream and degradation. Malathion and carbaryl in pond water would degrade rapidly because of hydrolysis and microbial breakdown. Although the acephate concentration in a pond is expected to be quite low, residues would remain for some time because of the slow degradation of acephate in water.

Table 4-14--Pesticide concentrations in water calculated for routine scenarios

Pesticide	Application rate (lb a.i. acre)	Parts per billion: Pond (4' deep)	Parts per billion: Stream (1' deep)
Malathion	0.58	4.0	16.0
Carbaryl	0.5	3.4	13.8
Acephate	0.094	0.65	2.6

Table 4-15--Pesticide concentrations in water calculated for accidental scenarios

Pesticide	Direct spraying of reservoir (ppb)	Jettison of load into reservoir (ppb)	Runoff from severe thunderstorms (ppb)	
			Reservoir	Stream
Malathion	26.6	5,300	0.44	2.94
Carbaryl	22.9	1,800	5.21	35.2
Acephate	4.3	220	5.66	38.2

Table 4-16--Comparison of toxicity reference values for malathion with estimated initial concentrations under the routine scenario

Representative species	Initial concentration (ppb)		96-hour LC_{50} [1/] (ppb)
	Pond	Stream	
Rainbow Trout	4.0	16.0	200
Bluegill	4.0	16.0	103
Channel Catfish	4.0	16.0	8,970
Fathead Minnow	4.0	16.0	8,650
Crayfish (Orconectes)	4.0	16.0	180
Scud (Gammarus sp.)	4.0	16.0	0.76
Stonefly (Pteronarcella)	NA[1/]	16.0	1.1

[1/]Technical Material 95%. Source: Johnson and Finley, 1980.
[2/]Not applicable, stoneflies generally occur only in lotic (flowing) waters.

The concentrations in water calculated for accidents are given in table 4-15.

Risk Analysis for Chemical Controls Under the Routine Scenario

Malathion. Expected concentrations of malathion are compared to the toxicity reference values (96-hour LC_{50}'s) for the representative species in table 4-16. No direct acute toxic

effects are expected in any of the fish species based on EPA criterion (estimated environmental concentration (EEC) of less than one-tenth the LC_{50}) (U.S. EPA, 1986a). Stream concentrations (where water depth is lower) are four times the pond concentrations. Channel catfish and fathead minnows have wide margins of safety for calculated concentrations of malathion in streams or ponds. The LC_{50}'s are well over 100 times greater than the expected concentrations. The LC_{50}'s for rainbow trout and crayfish are at least 10 times greater than the expected concentrations in a pond or stream.

Bluegill in ponds also would not be affected. Bluegill in a stream would be exposed to malathion concentrations of about one-sixth the LC_{50}. A temporary depression of acetylcholinesterase could occur in some fish. A small percentage of the bluegill population in the affected reach of stream could receive an acute lethal dose of malathion. The LC_{50} values in table 4-14 are based on 96-hour tests, but because of malathion's short half-life and quick clearance from the stream, individual fish may be exposed to the expected concentration only briefly. Impacts are generally less with shorter exposure times, and LC_{50}'s are higher when calculated for periods of shorter duration than 96 hours; that is, organisms exposed for shorter periods must be exposed to higher concentrations to experience acute lethal effects.

The expected concentration in streams of 16 ppb is at least 10 times greater than the LC_{50} for the representative species of aquatic invertebrates. Populations of *Gammarus* sp. and *Pteronarcella* are likely to experience heavy reductions in numbers in the affected reach of the stream. Losses of invertebrate species are generally expected to be temporary (as observed in studies reported in appendix A). More tolerant invertebrates may increase temporarily in abundance, and predatory fish may shift their feeding habits accordingly.

Because of the short half-life of malathion in water, no long-term toxic effects (such as decreased fertility or reduced growth rates) are expected for fish or invertebrates.

Carbaryl. The toxicity reference values (96-hour LC_{50}'s) for the representative species are compared to the expected concentrations in the routine scenario in table 4-17. For all fish species and crayfish, the highest concentration expected (13.8 ppb) is at least 100 times less than the LC_{50}'s for these species. No fish would be directly killed from exposure to carbaryl at these concentrations.

Stonefly (*Pteronarcella*) and scud (*Gammarus*) populations in the affected reach of a stream could decline in numbers.

Table 4-17--Comparison of toxicity reference values for carbaryl with estimated initial concentrations under the routine scenario

Representative species[1]	Initial concentration (ppb) Pond	Stream	96-hour LC_{50} (ppb)
Rainbow Trout	3.4	13.8	1,950
Bluegill	3.4	13.8	6,760[2]
Channel Catfish	3.4	13.8	15,800
Fathead Minnow	3.4	13.8	14,600
Crayfish (*Procambarus*)	3.4	13.8	1,900
Scud (*Gammarus* sp.)	3.4	13.8	22
Stonefly (*Pteronarcella*)	NA[3]	13.8	1.7

[1]Technical 99.5%; Source: Johnson and Finley, 1980.
[2]LC_{50} for Bluegill is 39,000 ppb with oil dispersion formulation 49% (Sevin 4-Oil).
[3]Not applicable, stoneflies generally occur only in flowing waters.

Aquatic insects are generally more sensitive to carbaryl than crustaceans and would experience more severe reductions. The LC_{50} values presented in table 4-17 are for the technical material. Tests with Sevin 4-Oil indicate that it is two to six times less toxic than the technical material; therefore, impacts would be proportionately less.

Because of the short half-life of carbaryl in aquatic environments, no long-term toxic effects to any organisms are expected. Risks to aquatic species when carbaryl bait is used would be lower because less chemical is likely to reach aquatic environments.

Diesel Oil and Petroleum Oil. Diesel and petroleum oil concentrations would be approximately 20 ppb in the stream and 5 ppb in the pond, assuming every 16 ounces of Sevin 4-Oil (which is about 46 percent petroleum oils) is mixed with 4 ounces of diesel oil (4:1 by volume). These concentrations are at least 60 times less than the 96-hour LC_{50} of 1,200 ppb reported for fresh-water fish exposed to diesel oil. (See appendix A for more details on diesel oil toxicity.) No fish are expected to be killed from exposure to these concentrations of diesel or petroleum oils.

Acephate. Table 4-18 compares the LC_{50} for the representative species with the concentrations expected in the routine scenario. For all representative species, the expected concentrations are much less than the LC_{50} value (EEC less than 1/1,000 of LC_{50}). No adverse effects are expected in any of these species.

Some fraction of acephate may be transformed to methamidophos in aquatic environments; however, specific rates of conversion have not been reported. It is assumed that the acute toxicity of whatever fraction of acephate that is converted to methamidophos would be accounted for in the laboratory-derived LC_{50} reported for the parent compound. It is also assumed that the rates of conversion of acephate to methamidophos under field conditions in the western States and in the laboratory toxicity tests are similar. Under these assumptions, no adverse effects are expected from any fraction of acephate that is converted to methamidophos.

Risk Analysis for Chemical Controls Under the Accidental Scenario

Malathion. Runoff from a heavy thunderstorm would not result in adverse effects on fish or crayfish. Scuds could experience some adverse effects in reservoirs receiving runoff.

Table 4-18--Comparison of toxicity reference values for acephate with estimated initial concentrations under the routine scenario

Representative species [1]	Initial concentration (ppm)		96-hour LC_{50} [2] (ppm)
	Pond	Stream	
Rainbow Trout	.00065	.0026	730
Bluegill	.00065	.0026	>1,000
Channel Catfish	.00065	.0026	560-1,000
Fathead Minnow	.00065	.0026	>1,000
Scud (Gammarus sp.)	.00065	.0026	>50[3]
Stonefly (Pteronarcella)	NA[4]	.0026	9.5[3]

[1]/LC_{50} not available for crayfish.
[2]/Soluble power 75% (Orthene 75s); Johnson and Finley, 1980.
[3]/Technical Material 94%; Johnson and Finley, 1980.
[4]/Not applicable, stoneflies generally occur only in flowing waters.

Stoneflies and scuds in a stretch of stream receiving runoff after a severe thunderstorm would suffer population reductions. See table 4-15 for the exposure concentrations and table 4-16 for the LC_{50}'s of the representative species.

Reservoirs being directly sprayed with malathion could be adversely affected. Rainbow trout, bluegill, and crayfish all have LC_{50}'s less than 10 times the exposure concentration. Some direct kills could result. Acetylcholinesterase levels in the fish could also be inhibited. The calculated exposure concentration (26.6 ppb) is much higher than the LC_{50} for Gammarus and these organisms could experience severe population reductions.

If a load of 200 gallons is jettisoned directly into a reservoir, most representative species would be adversely affected. All but the more tolerant fish species such as channel catfish and fathead minnows would probably be severely reduced in numbers.

Carbaryl. No fish or crayfish would be adversely affected from runoff from severe thunderstorms or the direct spraying of a reservoir. Scuds and stoneflies could suffer population reductions in a directly sprayed reservoir or in a stream receiving severe runoff.

The loss of a load of carbaryl into a reservoir may cause direct kills to some rainbow trout and crayfish. Their LC_{50}'s of 1,950 ppb and 1,900 ppb, respectively, are only slightly above the expected concentration of 1,800 ppb. Stoneflies and scuds would be severely depleted. See table 4-15 for the exposure concentrations and table 4-17 for the toxicity reference values.

Risks to aquatic species from the use of carbaryl bait in grasshopper control operations would be less than those described for carbaryl spray.

Diesel Oil and Petroleum Oil. Runoff from a heavy thunderstorm would result in estimated concentrations of 14 ppb in a reservoir and 93 ppb in a stream. These values are both at least 10 times less than the 96-hour LC_{50} of 1,200 ppb and no fish mortalities are expected.

Diesel oil concentrations in a reservoir directly sprayed are estimated to be 33 ppb. This also is well below the LC_{50}.

If a load is jettisoned into a reservoir, diesel and petroleum oil concentrations would be approximately 2.6 ppm, assuming Sevin 4-Oil is mixed 4:1 with diesel oil. This concentration is higher than the 96-hour LC_{50} for fresh-water fish of 1.2 ppm. Fish kills could result from the direct toxic effects of

those oils. Aquatic invertebrates also would probably be adversely affected.

Acephate. The expected concentrations resulting under the accidental scenarios (table 4-15) are all at least 10 times less than the LC_{50}'s for the most sensitive species. No adverse impacts are expected from any accident with acephate. See table 4-18 for the toxicity reference levels.

Impacts of Multiple Chemical Applications

A repeated application of malathion 4 weeks after the initial application would not result in adverse impacts that are greater than those described under the routine and accidental scenarios. Malathion has a very short half-life and would be quickly degraded in water. After 4 weeks, only 2.4×10^{-6} of the initial amount of malathion in water would be remaining. This would be insignificant when added to the amount from another application. Carbaryl also has a very short half-life in water. At 4 weeks, only 1.6×10^{-3} of the initial carbaryl concentration would be remaining. This would be insignificant when added to the amount from a repeated application of carbaryl.

The aromatic component of diesel oil, which is also the main toxic component (Connell and Miller, 1984), has a half-life in water of 2 to 10 days. Therefore, after 28 days, only 0.039 of the initial aromatic concentration will be remaining in the water. This amount would not add significantly to the amount expected from a repeated application.

Because of label restrictions, repeated applications of acephate on rangelands would not be conducted within the same season.

Impacts of Biological Control

Nosema has no known adverse effects on nontarget organisms or the environment. No adverse effects are expected on aquatic environments.

Potential Impacts on Endangered and Threatened Aquatic Species

APHIS is committed to ensuring that any alternative chosen under the grasshopper control program complies with the Endangered Species Act. The three insecticides--malathion, acephate, and carbaryl--have been found to exhibit a high biodegradability in soil and water and no bioaccumulation in food chains, but some pickup by aquatic organisms may occur during direct exposure.

A depression in the population of aquatic insects may result after treatment. Although migrations of terrestrial insects in avoidance of the treatment zone often result in an added food source for predators of insects, consideration should be given to this potential loss in the food chain.

The toxicity of the insecticides to fish is low to moderate. The malathion label warns of its toxicity to fish, shrimp, and crabs and prohibits its use over water. EPA lists carbaryl and malathion as pesticides that may affect endangered aquatic species (U.S. EPA, 1986b).

Current operational procedures include a 500-foot buffer zone for chemical spray treatments around specified water bodies supporting higher life and a 200-foot buffer zone for carbaryl bait around these water bodies. Reservoirs, lakes, ponds, pools left by seasonal streams, springs, wetlands, and perennial streams or rivers are included in the buffer zones. Spraying is not allowed when winds exceed 10 miles per hour or when rain is imminent.

The potential impacts of grasshopper control treatments on endangered and threatened aquatic species and proposed protection measures are presented in the 1987 Biological Assessment. APHIS is committed to comply with all protection measures developed and documented through consultation with the Fish and Wildlife Service. Site-specific environmental assessments will address impacts to federally listed species, candidate species, State-listed species, or other species of concern in a proposed treatment area.

Impacts of Grasshopper Control Alternatives

No Action

If grasshopper infestations are not controlled, the severe loss of grasses and other protective ground cover could result in increased soil erosion. Soil particles would be carried into nearby streams and bodies of water by wind and runoff. Increased turbidity can decrease the amount of sunlight penetrating the water column resulting in decreased growth of aquatic plants and algae. This could reduce the total productivity within an aquatic community or shift the aquatic community species composition to one that is less desirable.

Chemical Control Alternative

The risks of each chemical to aquatic species (as described in the previous sections) could occur under this alternative. In general, malathion is moderately toxic, carbaryl is much less toxic, and acephate is relatively nontoxic to fish. Acetylcholinesterase depression could occur but is not considered significant. Some changes in fish feeding behavior have been observed in field studies. Aquatic insects are very sensitive to these chemicals, and reductions in populations could occur if water bodies receive chemicals by direct spray, spills, or runoff. Based on other field studies, these population reductions are likely to be temporary, with recovery occurring in several weeks.

Diesel oil would not have toxic effects on fish at the expected concentrations under the routine scenario. Direct kills from diesel oil could occur from a load spilled into a reservoir. The effects to aquatic species from exposure to methamidophos are accounted for in the risks described for the parent compound, acephate, as explained above.

The possibility of chemical pesticides reaching water and the resulting impacts on aquatic species may vary from region to region. Large rivers, such as the Columbia in the northwest and the Missouri in the Great Plains, would not be very susceptible to the impacts of pesticide drift because of dilution from their large volumes and rapid flow rates.

Prairie potholes and small farm ponds in the tall-grass and short-grass prairies would be susceptible to drift because they are small and have a negligible rate of freshwater inflow. Streams in these regions tend to be sluggish and, as a result, would also be more susceptible to drift impacts than fast-moving waters. Mountain streams have rapid flow rates, which would lessen impacts from drift.

In the Great Basin, desert, and plateau regions, streams and other surface waters are scarce; therefore, the chance of pesticides drifting to aquatic environments is low. Also important are regional differences in climate such as temperature, precipitation, humidity, percentage of sunlight, and atmospheric turbulence; edaphic factors (such as soil type); topography; water quality (such as pH); and percentage of vegetative cover--all of which may affect the degradation and transport of a pesticide in the environment.

IPM Alternative

Under this alternative, a smaller amount of chemicals would be used than under the chemical control alternative. Impacts resulting from the use of chemicals would be proportionately less. The use of Nosema is not expected to result in any adverse impacts to the aquatic environment.

HUMAN HEALTH EFFECTS

Impacts of Chemical Grasshopper Control Methods

This section presents the results of the risk assessment conducted to assess the potential effects of the alternative grasshopper control chemicals on workers and members of the public. The first part of this section, the hazard analysis, summarizes the findings of laboratory toxicity studies. Full details of those studies are given in appendix A. The second part gives the results of the exposure analysis. The detailed methods of the exposure analysis, outlined previously in this chapter, are given in appendix B. The third part of this section presents the risk analysis for each chemical to humans.

Some of the language in this section on human health effects is necessarily technical. Words like oncogenic (which means able to cause tumors), teratogenic (which means capable of causing malformations (birth defects) in unborn offspring), mutagenic (capable of causing changes), and carcinogenic (capable of causing cancer) are used throughout. These and other technical terms are defined for the reader in appendix E, the glossary.

Under routine circumstances and given compliance with the operational procedures, no significant health impacts to workers or the general public are expected from the use of any of the three chemicals in grasshopper control activities. Malathion or acephate exposures to sensitive individuals may cause some symptoms of cholinesterase inhibition even under routine circumstances. These symptoms could include dizziness, headache, or nausea. Similar effects could occur to sensitive members of the pulbic in the case of accidental direct spraying or spraying of a leafy crop. Smaller accidental exposures, for example, direct spraying of a reservoir, are unlikely to cause significant adverse effects. An accidental spill of any of the three chemicals on a worker could result in moderate to severe symptoms of cholinesterase inhibition (described below), such as vomiting, abdominal cramps, blurred vision, and loss of muscle control.

Hazard Analysis of Chemical Controls

The hazard of each chemical to human health is discussed in detail in appendix A. Table 4-19 summarizes the relevant toxicity reference values for the three chemicals, diesel oil, formaldehyde, and methamidophos.

One major characteristic shared by the three chemicals--malathion, carbaryl, and acephate--is that they are all "cholinesterase inhibitors." Cholinesterases (including acetylcholinesterase) are enzymes that function at the nerve synapse, which is the point where information in the form of electrical impulses is relayed or transmitted by chemical messengers (called transmitters) from one nerve cell to another. Cholinesterase then inactivates or destroys the transmitter chemical (like acetylcholine) after it completes its job, otherwise the transmitter would continue indefinitely and precise control of the enervated tissue (muscle or organ) would be lost.

Malathion. Malathion is classified as a moderately toxic organophosphate insecticide. Malathion and its metabolite malaoxon are cholinesterase inhibitors. Two bioassays that tested for oncogenic potential (ability to cause tumors) in rats and mice were negative. Another oncogenic bioassay of malaoxon also was negative. There have been no reported

Table 4-19--Toxicity reference values for malathion, carbaryl, acephate, formaldehyde, diesel oil, and methamidophos (in mg/kg).

	Malathion	Carbaryl	Diesel Oil	Formaldehyde	Acephate	Methamidophos
Dermal LD_{50}	>4,444	>5,000	>3,280	270	10,250	118
Oral LD_{50}	370	270	7,380	800	866	7.5
Lowest NOEL	0.2	1.8	--	--	0.25	0.02
ADI	0.02	0.1	--	--	0.0025	--

teratogenic effects (birth defects) observed in test animals as a result of malathion administration; however, reproductive effects have been observed. Malathion was mutagenic (causing genetic mutations) when tested in an *in vivo* assay of human cells and nonmutagenic in eight microbial assays.

Carbaryl. Carbaryl is a moderately toxic carbamate insecticide. The major toxic effects observed in laboratory test animals and human exposure studies are depressed neurotransmitter enzyme (cholinesterase) levels and altered kidney function and histology. Both toxic effects were reversible and did not result in permanent damage. The neurotoxic effects produced by carbaryl did not result in nervous tissue lesions or nerve cell damage. Chronic feeding studies in two test species did not result in tumors. EPA has concluded that the available evidence does not indicate that carbaryl is a potential human teratogen. Carbaryl has been classified as a weak mutagen because of the induction of chromosomal aberrations and other adverse effects on cell division in mutagenicity assays.

The carbaryl formulation Sevin XLR Plus contains 0.1 percent formaldehyde as a preservative. Formaldehyde is a slightly toxic chemical, with an LD_{50} for rats of 800 mg/kg. Formaldehyde is a skin and respiratory tract irritant, and a dermal sensitizer. After sensitivity is induced, further exposure can illicit an allergic response. Formaldehyde has been classified by EPA as a probable human carcinogen. It has been placed in Group B_1, indicating that there is sufficient evidence of carcinogenicity from animal studies and limited evidence of carcinogenicity in humans. Based on available evidence, the Concensus Workshop on Formaldehyde concluded that formaldehyde acts as a weak mutagen. However, none of the genetic toxicity data were considered sufficient by EPA for regulatory purposes. Additional genetic toxicity tests have been requested by EPA. No teratogenic effects or impairment of reproductive function have been reported for formaldehyde.

Diesel Oil. Diesel oil is classified as a very slightly toxic mixture based on its acute oral toxicity. Diesel oil is not irritating to the eyes, but it is a skin irritant. Diesel oil does not cause teratogenic effects, but it has been shown to cause chromosomal abnormalities in rat bone marrow cells. Although diesel oil has not been shown to cause cancer, it is likely to have a slight carcinogenic potency because it contains small amounts of chemicals known or suspected to cause cancer. Among these are benzene and benzo(a)pyrene.

Acephate. Acephate is classified as a moderately toxic insecticide. Acephate has produced neurotoxic effects in laboratory animals as a result of the depression of neurotransmitter

enzyme (cholinesterase) levels at nerve junctions. Laboratory testing of the acephate impurity methylthioacetate has resulted in damage to the optic tracts and pituitary glands of test animals. A significant increase in liver tumors at the highest dose tested was observed during a 2-year oncogenic study in male mice. There were no teratogenic effects observed as a result of exposure to acephate. Acephate tested positive for mutagenicity in both in vitro and in vivo assays of human cells, mammalian cells, and microbial cells.

Methamidophos. Methamidophos is classified as a very toxic insecticide. Toxic effects in humans and laboratory animals occur in the nervous system resulting from cholinesterase inhibition, and in the eyes and skin. Methamidophos was not observed to be teratogenic in rabbits. A chronic feeding study did not result in tumors in rats. Mutagenic effects did not occur in mice injected with methamidophos.

Exposure Analysis of Chemical Controls

Malathion ULV Spray. Human exposures to malathion are given in table 4-20 under various exposure scenarios. Under the routine scenario, pilots have an estimated dose of 2.0×10^{-3} mg/kg, whereas doses to mixer/loaders are approximately 2.4 times greater (4.7×10^{-3} mg/kg). The highest exposure to workers or members of the public standing 500 feet downwind of a large sprayed area would be by means of the dermal route at 9.1×10^{-4} mg/kg. Inhalation exposure is only about 1.6 percent as great at 1.5×10^{-5} mg/kg. Dietary exposures are potentially higher. A person eating quail from a sprayed area could receive about 3.9×10^{-2} mg/kg. Exposure from eating other meats, such as beef, or fish from water downwind of a sprayed area, would be less. Grains from a sprayed area could contribute 1.8×10^{-2} mg/kg. The dose received from eating leafy vegetables would be almost 12 times greater (described below in the accidental scenario).

It should be remembered that these are maximum doses in the sense that conditions were assumed to be conducive to exposure, no degradation was assumed, and vegetables were assumed to be eaten without washing. Preharvest intervals required by the labels were assumed to be disregarded. If a resident received direct exposure at 500 feet downwind of a sprayed area and also included multiple contaminated items in his or her diet, then the total exposure could be as high as 0.058 mg/kg.

Exposures to the public under the accidental scenarios may be greater. Direct spraying of an unregistered leafy vegetable would produce doses that are at most 0.208 mg/kg. Direct spraying of a small child (with 40 percent bare skin) could produce a dose of 7.4×10^{-2} mg/kg, 6 times higher than for a normally clothed adult. Jettison of an aircraft load (200

Table 4-20--Human exposures to malathion and associated margins of safety

	Dose (mg/kg body weight)	Margin of safety[1]
Workers - Routine		
Pilot	2.0×10^{-3}	100
Mixer/loader	4.7×10^{-3}	42
Workers at 500 feet	9.23×10^{-4}	217
Workers - Accidental		
Direct spraying	1.21×10^{-2}	16
Spill of concentrate	2.06×10^{2}	-1,030
Public - Routine		
Dermal exposure at 500 feet	9.08×10^{-4}	220
Inhalation exposure at 500 feet	1.49×10^{-5}	13,423
Oral exposure		
Grain (directly sprayed)	1.8×10^{-2}	11
Fish (from water receiving drift)	5.71×10^{-5}	3,503
Jackrabbit (from sprayed area)	9.07×10^{-3}	22
Quail (from sprayed area)	3.85×10^{-2}	5.2
Beef (from sprayed area)	1.93×10^{-3}	104
Water (containing spray drift)	1.14×10^{-4}	1,754
Total (via dermal, inhalation, grain, water, and highest meat)	5.8×10^{-2}	3.4
Public - Accidental		
Direct spraying of child	7.40×10^{-2}	2.7
Direct spraying of unregistered crop (leafy vegetable)	2.08×10^{-1}	-1.0
Contaminated drinking water		
Directly sprayed reservoir	3.8×10^{-4}	526
Jettison of aircraft load into reservoir	7.6×10^{-2}	2.6
Runoff from severe thunderstorm into reservoir	6.21×10^{-6}	32,206

[1] Margin of Safety = $\dfrac{\text{Lowest NOEL of 0.2 mg/kg}}{\text{Estimated Dose}}$

gallons) into a 16-acre reservoir would give a dose of 0.076 mg/kg to a person who subsequently drank 1 liter of the water.

Workers have a much higher potential for accidental exposure. A spill of 1/2 liter of malathion concentrate could produce a dose of 206 mg/kg if the worker did not change his clothes and wash (as program guidelines require).

Carbaryl Spray. Human exposures to carbaryl are given in table 4-21 for the various exposure scenarios. Routine doses to mixer/loaders (5.7×10^{-3} mg/kg/day) are approximately 2.4 times greater than doses to pilots (2.4×10^{-3} mg/kg/day). The highest routine exposures to workers or members of the public standing 500 feet downwind of a large sprayed area would be 1.13×10^{-3} mg/kg for a combination of dermal and inhalation routes. The exposure is expected to be about 99 percent dermal and only about 1 percent by inhalation. As in the case of malathion, dietary exposures are potentially higher. A person eating quail from a sprayed area could receive about 3.3×10^{-2} mg/kg. Exposure from eating beef would not be more than 1.6×10^{-3} mg/kg, and fish or drinking water exposures would be considerably less. Grains from a sprayed area could contribute a dose of 1.5×10^{-2} mg/kg if they were eaten the same day they were sprayed without washing. If a resident received direct exposure at 500-feet downwind of a large sprayed area and also included multiple contaminated items in his diet, then total exposure could be as high as 0.050 mg/kg.

Direct spraying of a crop for which the pesticide is not registered could produce a dose of 0.18 mg/kg if it is a leafy crop. Other accidental exposures to the public would be less. Direct spraying of a small child could produce a dose of 9.1×10^{-2} mg/kg. Jettison of a 200-gallon load into the example reservoir would give a dose of 2.63×10^{-2} mg/kg to a person drinking 1 liter of that water.

Workers handling concentrated Sevin 4-Oil have a higher potential for accidental exposure. A spill of 1/2 liter of concentrate could produce a dose of about 127 mg/kg if the worker did not change his clothes and wash.

Human dermal or dietary exposures to formaldehyde present in the formulation Sevin XLR Plus will be at most 0.001 times those listed in table 4-21 for carbaryl. Exposures are likely to be less in most cases because of the short half-life of formaldehyde (about 6 hours in sunlight). The inhalation component of exposure may be relatively greater for formaldehyde because of its volatility, but formaldehyde exposures will be less than 0.00045 mg/kg body weight.

Table 4-21--Human exposures to carbaryl and associated margins of safety

	Dose (mg/kg body weight)	Margin of Safety[1/]
Workers - Routine		
Pilot	2.4×10^{-3}	750
Mixer/loader	5.7×10^{-3}	316
Worker at 500 feet	1.13×10^{-3}	1,593
Workers - Accidental		
Direct spraying	1.49×10^{-2}	121
Spill of concentrate	1.27×10^{2}	-100
Public - Routine		
Dermal exposure at 500 feet	1.12×10^{-3}	1,607
Inhalation exposure at 500 feet	1.29×10^{-5}	139,535
Oral exposure		
Grain (directly sprayed)	1.5×10^{-2}	120
Fish (from water receiving drift)	4.93×10^{-5}	36,511
Jackrabbit (from sprayed area)	7.86×10^{-3}	229
Quail (from sprayed area)	3.34×10^{-2}	54
Beef (from sprayed area)	1.64×10^{-3}	1,098
Water (containing spray drift)	9.86×10^{-5}	18,256
Total (via dermal, inhalation, grain, water, and highest meat)	5.0×10^{-2}	36
Public - Accidental		
Direct spraying of child	9.11×10^{-2}	20
Direct spraying of unregistered crop (leafy vegetable)	1.79×10^{-1}	10
Contaminated drinking water		
Directly sprayed reservoir	3.27×10^{-4}	5,505
Jettison of aircraft load into reservoir	2.63×10^{-2}	68
Runoff from severe thunderstorm into reservoir	7.44×10^{-5}	24,193

[1/]Margin of Safety = $\frac{\text{Lowest NOEL of 1.8 mg/kg}}{\text{Estimated Dose}}$

Diesel Oil. Human exposures to diesel oil contained in carbaryl sprays are listed in table 4-22 for the various exposure scenarios. Routine doses to mixer/loaders are 2.4 times greater than doses to pilots. The highest exposures to workers or members of the public standing 500 feet downwind of a large sprayed area would be 3.44×10^{-3} mg/kg for a combination of dermal and inhalation routes. Again, the exposure is more than 99 percent by the dermal route and less than 1 percent by inhalation. Dietary exposures are potentially higher. The dietary exposure from eating grains that had been directly sprayed and not washed would be 1.87×10^{-2} mg/kg. A person eating quail

Table 4-22--Estimated doses of diesel oil to humans (mg/kg body weight)

Workers - Routine	
Pilot	7.0×10^{-3}
Mixer/loader	1.7×10^{-2}
Worker at 500 feet	3.44×10^{-3}
Workers - Accidental	
Direct spraying	4.54×10^{-2}
Spill of concentrate	3.87×10^{2}
Public - Routine	
Dermal exposure at 500 feet	3.42×10^{-3}
Inhalation exposure at 500 feet	1.57×10^{-5}
Oral exposure	
Grain (directly sprayed)	1.87×10^{-2}
Fish (from water receiving drift)	7.58×10^{-4}
Jackrabbit (from sprayed area)	1.13×10^{-2}
Quail (from sprayed area)	7.66×10^{-2}
Beef (from sprayed area)	2.30×10^{-3}
Water (containing spray drift)	1.20×10^{-4}
Total (via dermal, inhalation, grain, water, and highest meat)	9.9×10^{-2}
Public - Accidental	
Direct spraying of child	2.78×10^{-2}
Direct spraying of unregistered crop (leafy vegetable)	2.18×10^{-2}
Contaminated drinking water	
Directly sprayed reservoir	3.99×10^{-4}
Jettison of aircraft load into reservoir	3.21×10^{-2}
Runoff from severe thunderstorm into reservoir	9.08×10^{-5}

from a sprayed area could receive about 7.7×10^{-2} mg/kg, or about 1.1×10^{-2} mg/kg from eating jackrabbit. A person eating beef from a sprayed area could receive about 2.3×10^{-3} mg/kg, and a person eating fish or drinking water would receive considerably less. If a resident received a direct exposure 500-feet downwind of a large sprayed area and also consumed multiple contaminated items, then his total exposure could be as high as 0.099 mg/kg.

Under the accidental scenario, direct spraying of a leafy crop for which the pesticide is not registered could produce a dose of 0.22 mg/kg. A child directly sprayed could receive a dose of about 0.28 mg/kg. Other accidental exposures to the public are considerably less. Jettison of an aircraft load into a reservoir could produce a dose of 3.2×10^{-2} mg/kg.

Workers handling diesel oil have the highest potential for accidental exposure. A spill of 1/2 liter of diesel oil could produce a dose of about 387 mg/kg <u>if</u> the worker did not change his clothes and wash.

<u>Acephate Spray</u>. Human exposures to acephate are given in table 4-23 for the various exposure scenarios. Routine doses to pilots are 4.5×10^{-4} mg/kg/day and 1.1×10^{-3} mg/kg/day to mixer/loaders. The highest exposures to workers or members of the public standing 500-feet downwind of a large sprayed area would be 2.1×10^{-4} mg/kg. Again, this exposure is about 99 percent through the dermal route and only about 1 percent via inhalation. Dietary exposures are potentially higher. A person eating quail from a sprayed area could receive about 6.3×10^{-3} mg/kg. Exposure from eating beef would be only 2.9×10^{-4} mg/kg, and doses from eating fish or drinking water would be less. Eating grains from a sprayed area soon after spraying could contribute a dose of 2.88×10^{-3} mg/kg if they are not washed. If a resident received direct exposure at 500-feet downwind of a large sprayed area and also included multiple contaminated items in his diet, then the total exposure could be as high as 0.040 mg/kg.

Under the accidental scenario, direct spraying of an unregistered crop could produce a dose of 3.4×10^{-2} mg/kg if it is a leafy crop. Other accidental exposures to the public would be less. Direct spraying of a small child could produce a dose of 1.7×10^{-2} mg/kg. Jettisoning of a 200-gallon load into the reservoir would give a dose of 3.10×10^{-3} mg/kg to a person drinking 1 liter of the water.

Workers handling acephate spray mixture have a higher potential for exposure by accidents. A spill of 1/2 liter of mixture could produce a dose of about 12 mg/kg <u>if</u> the worker did not change his clothes and wash.

Table 4-23--Human exposures to acephate and associated margins of safety

	Dose (mg/kg body weight)	Margin of safety[1/]
Workers - Routine		
Pilot exposure	4.5×10^{-4}	555
Mixer/loader exposure	1.1×10^{-3}	227
Worker at 500 feet	2.12×10^{-4}	1,179
Workers - Accidental		
Direct spraying	2.80×10^{-3}	89
Spill of concentrate	11.9	-50
Public - Routine		
Dermal exposure at 500 feet	2.10×10^{-4}	1,190
Inhalation exposure at 500 feet	2.40×10^{-6}	104,167
Oral exposure		
Grain (directly sprayed)	2.88×10^{-3}	87
Fish (from water receiving drift)	9.29×10^{-5}	2,691
Jackrabbit (from sprayed area)	1.50×10^{-3}	167
Quail (from sprayed area)	6.29×10^{-3}	40
Beef (from sprayed area)	2.9×10^{-4}	862
Water (containing spray drift)	1.86×10^{-5}	13,441
Total (via dermal, inhalation, grain, water, and highest meat)	4.0×10^{-2}	6.2
Public - Accidental		
Direct spraying of child	1.71×10^{-2}	15
Direct spraying of unregistered crop (leafy vegetable)	3.36×10^{-2}	7.4
Contaminated drinking water		
Directly sprayed reservoir	6.14×10^{-5}	4,072
Jettison of aircraft load into reservoir	3.10×10^{-3}	81
Runoff from severe thunderstorm into reservoir	8.08×10^{-5}	3,094

[1/]Margin of safety = $\frac{\text{Lowest NOEL of 0.25 mg/kg}}{\text{Estimated Dose}}$

Methamidophos. The estimated doses to humans of methamidophos from application of acephate are given in table 4-24. Most of these exposures are approximately 6 to 30 percent of those for acephate (table 4-23). These values are based on the following rates of transformation of acephate to methamidophos: 10 percent in mammals, birds, water, and plants; 6 percent in fish; 29 percent in insects; and no conversion in air (see appendix B). Details on concentrations in game and livestock food items are provided in the wildlife risk analysis.

Risk Analysis for Chemical Controls

The risk analysis compares estimated exposures to each chemical to two values in order to address the possible effects to workers and the public from APHIS grasshopper control operations. First, the estimated exposures to each chemical under routine and accidental scenarios have been compared to the lowest NOEL derived for that chemical to develop a ratio known as the margin of safety (see tables 4-20, 4-21, and 4-23). The margin of safety is used to account for the uncertainty inherent in relating doses and effects seen in animals to doses and effects seen in humans. For example, a margin of safety of 100 means the laboratory-determined no-effect level is 100 times the estimated dose to humans.

The larger the margin of safety, the lower the risk to human health. When an estimated dose exceeds a NOEL (giving a margin of safety of less than one), the ratio is reversed (the dose is divided by the NOEL) to indicate how high the estimated dose is above the laboratory no-effect level and a minus sign is used to indicate that the estimated dose exceeds the NOEL. A margin of safety of -3, for example, means that the estimated dose is 3 times the laboratory-determined no-effect level. It can be inferred from a negative margin of safety that the estimated dose (given all the assumptions of the exposure situation) indicates some possibility of toxic effects, although it must be remembered that the margin of safety is based on a laboratory dose level that produced no toxic effects in test animals. When repeated doses to humans are much higher than the animal NOEL, there is a clear risk of harmful effects. Conversely, when the human dose is small compared with the animal NOEL (giving a margin of safety greater than 100), the risk to humans can be judged negligible.

A second means of indicating possible effects on workers and public health is to compare estimated exposures to the ADI. As explained earlier in the chapter, safety factors are applied to NOEL's to determine the acceptable daily intake, which, according to EPA, is the maximum dose of chemical that can be taken every day over a lifetime without any adverse

Table 4-24--Human exposures to methamidophos from application of acephate and associated margins of safety

Route of Exposure	Dose (mg/kg body weight)	Margin of safety[1/]
Workers - Routine		
Pilot exposure	4.5×10^{-5}	444
Mixer/loader exposure	1.1×10^{-4}	182
Worker at 500 feet	2.1×10^{-5}	952
Workers - Accidental		
Direct spraying	2.8×10^{-4}	71
Spill of concentrate	1.2	-60
Public - Routine		
Dermal exposure at 500 feet	2.1×10^{-5}	952
Inhalation exposure at 500 feet	0	--
Oral exposure		
Grain (directly sprayed)	2.9×10^{-4}	69
Fish (from water receiving drift)	5.9×10^{-6}	3,390
Jackrabbit (from sprayed area)	3.1×10^{-4}	64
Quail (from sprayed area)	2.1×10^{-3}	9.5
Beef (from sprayed area)	5.7×10^{-5}	351
Water (containing spray drift)	1.9×10^{-6}	10,500
Total (via dermal, inhalation, vegetable, water, and highest meat)	2.4×10^{-3}	8.3
Public - Accidental		
Direct spraying of child	1.7×10^{-3}	12
Direct spraying of unregistered crop	3.4×10^{-3}	5.9
Contaminated drinking water		
Directly sprayed reservoir	6.1×10^{-6}	3,280
Jettison of aircraft load into reservoir	3.1×10^{-4}	65
Runoff from severe thunderstorm into reservoir	8.1×10^{-6}	2,470

[1/]Margin of safety = $\frac{\text{Lowest NOEL of 0.02 mg/kg}}{\text{Estimated Dose}}$

0.02 mg/kg/day is based on a NOEL of 0.1 mg/kg/day in humans for a 1:4 mixture of methamidophos:acephate (U.S. EPA, 1982c).

effect. Table 4-25 indicates when the estimated exposures for malathion, carbaryl, and acephate exceed the ADI under routine and accidental circumstances.

Because findings regarding the carcinogenicity of the chemicals and their conversion products or metabolites are inconclusive (see appendix A), a theoretical cancer risk analysis is also presented for each. Because no known cases of human cancer have been caused by any of the three chemicals being considered, data on laboratory test animals were used to assign theoretical cancer potency values.

<u>Malathion</u>. The lowest margin of safety for a worker during routine operations is 42 (for the mixer/loader). A worker or member of the public receiving both dermal and inhalation malathion doses at 500-feet downwind of a spray block would receive a dose that is lower than the NOEL with a margin of safety of 217. (See table 4-20.) Members of the public could receive a dose lower than the lowest NOEL by a factor of 5.2 by eating quail from a sprayed area. Under routine conditions, estimated doses exceed the ADI levels only for eating contaminated quail. (See table 4-25.)

All other routine doses are below EPA's ADI value set for lifetime exposure. Therefore, adverse health effects would not be expected. The highest possible exposures (from multiple sources) under routine conditions are about 30 percent of the lowest NOEL and exceed EPA's ADI. Thus, there is a risk of adverse health effects from exposures from multiple sources. However, because these exposures would occur only once every 7 years, the risk can be considered low when compared to NOEL's and ADI's set over lifetime exposure. In very sensitive individuals, however, some symptoms of cholinesterase inhibition may occur. These may include dizziness, headache, or nausea.

The margin of safety for accidental exposures to the public in the case of an emergency jettison is only 2.6. A spill of concentrate on a worker could produce a dose with a margin of safety of -1,030. However, this dose is still only about one-half of the oral LD_{50}. Death is not likely to result, but symptoms of cholinesterase inhibition would occur. Typical symptoms include headache, dizziness, nausea, vomiting, diarrhea, and blurred vision. These symptoms would be reversible. Death could occur from accidental exposures to unusually sensitive individuals from heartblock or respiratory failure. The history of occupational exposure to this chemical indicates that this is an extremely remote possibility. If workers follow standard operational procedures, there will be little possibility of death.

Lifetime doses to workers (mixer/loaders) after 30 years, with 20 spray days per year, are estimated to be 1.1×10^{-4} mg/kg

Table 4-25--Comparison of estimated doses to humans for grasshopper control treatments with acceptable daily intake (ADI) values established by EPA for malathion, carbaryl, and acephate

	Malathion	Carbaryl	Acephate
Workers - Routine			
Pilots -	-1/	-	
Mixer/loaders	-	-	-
Dermal exposure at 500 feet	-	-	-
Inhalation exposure at 500 feet	-	-	-
Total	-	-	-
Workers - Accidental			
Direct spraying	-	-	+
Spill of concentrate	+2/	+	+
Public - Routine			
Dermal exposure at 500 feet	-	-	-
Inhalation exposure at 500 feet	-	-	-
Oral exposure			
Grain (directly sprayed)	-	-	+
Fish (from water receiving drift)	-	-	-
Jackrabbit (from sprayed area)	-	-	-
Quail (from sprayed area)	+	-	+
Beef (from sprayed area)	-	-	-
Water (containing spray drift)	-	-	-
Total (via dermal, inhalation, grain, water, and highest meat)	+	-	+
Public - Accidental			
Direct spraying of child	+	-	+
Direct spraying of unregistered crop (leafy vegetable)	+	+	+
Contaminated drinking water			
Directly sprayed reservoir	-	-	-
Jettison of aircraft load into reservoir	+	-	+
Runoff from severe thunderstorm into reservoir	-	-	-

1/- = Estimated dose below ADI.
2/+ = Estimated dose exceeds ADI.

per day. If an accident consisting of a concentrate spill is added to the lifetime dose, then the average is 8.3×10^{-3} mg/kg per day. An average lifetime dose for a member of the public receiving exposures by dermal, inhalation, and oral routes every 7 years averages 2.3×10^{-4} mg/kg per day.

A recent review by the National Toxicology Program (NTP) reevaluated studies on the carcinogenicity of malathion and its metabolite malaoxon (Huff et al., 1985). The review confirmed the original conclusion of the National Cancer Institute that malathion was not carcinogenic. However, NTP concluded that there was equivocal evidence of carcinogenicity for male and female F344 rats for malaoxon because of C-cell neoplasms of the thyroid gland. Consequently, lifetime cancer risks were calculated for malathion to estimate the maximum possible risk of carcinogenesis or mutagenesis. A cancer potency estimate of 0.02 $(mg/kg/day)^{-1}$ was used for the linear model, based on calculations by the California Department of Health Services (1980). Combining this potency with the lifetime doses given above, the risks shown in table 4-26 were calculated. The risk of cancer for the public exposed to malathion in grasshopper control treatments is at most 5 chances in 1 million. A mixer/loader under ordinary circumstances can expect about 2 chances in 1 million, but accidental exposure to concentrate can increase the risk substantially. The risk calculated under the concentrate spill scenario is 1.6 chances in 10,000.

The cancer risk resulting from exposure to the insecticide can be compared to the background risk to the general public of getting cancer to see how the risks from exposure compare to the public's cancer risk in general. The background risk can be estimated based on average statistics for the United States. These statistics in recent years indicate that one in every four Americans will suffer from cancer during their lifetime, and one in every five will die from cancer (U.S. DHHS, 1985).

Table 4-26--Maximum theoretical lifetime cancer risks for malathion

Exposure category	Lifetime cancer risk
Worker (mixer/loader, 30 years)	2.2×10^{-6}
Worker, with concentrate spill	1.6×10^{-4}
Public (multiple exposures)	4.6×10^{-6}

Risks of death from other commonly known causes are listed in table 4-27 for comparison with results from these analyses.

Carbaryl Spray. Under routine conditions, a worker or member of the public receiving both dermal and inhalation doses at 500-feet downwind of a large spray block would receive a dose that is lower than the NOEL with a margin of safety of approximately 1,600 (see table 4-21). A mixer/loader under routine conditions could receive a dose with a margin of safety of 316. This compares with the safety factor of 18 that EPA used in setting the ADI. If members of the public eat quail from a sprayed area, they could receive a dose that is lower than the lowest NOEL by a margin of safety of 54.

Inhalation and dermal exposures under routine conditions would have little potential for producing adverse effects. Even the highest possible oral exposures are not likely to cause any effects on the public. Allowable concentrations of formaldehyde gas in workplaces (1 to 3 ppm) are at least 40 to 125 times greater than those that could be encountered after treatments with Sevin XLR Plus.

The highest accidental exposure to the public would be from eating a leafy vegetable soon after spraying. The margin of safety in this case would be 10. Other accidental exposures have much higher margins of safety. Jettisoning of carbaryl into a reservoir would produce a dose that is almost a factor of 70 less than the NOEL. Table 4-25 gives a comparison between estimated doses and ADI levels. The only doses exceeding the ADI are from accidental spills of concentrate or spraying of a leafy crop.

An accidental spill of Sevin 4-Oil concentrate onto a worker could produce a dose that is 100 times greater than the NOEL, and nearly half of the oral LD_{50}. Death is still not likely to occur even with this high dose, but severe symptoms of cholinesterase inhibition would occur. Likely symptoms include vomiting, abdominal cramps and diarrhea, weakness, dizziness, blurred vision, sweating, and ineffective muscle control. These effects are reversible. Unusually sensitive individuals may die as a result of heartblock or respiratory failure, but the unusually good safety record of carbaryl (Cranmer, 1986) indicates that death is highly unlikely. If workers follow prescribed procedures in the event of a spill, there will be little risk of death. Repeated accidental dermal exposure to Sevin XLR Plus concentrate would be likely to produce an allergic reaction in a small fraction (less than 5 percent) of workers.

Lifetime doses to workers (mixer/loaders) after 30 years of employment are estimated to average 1.4×10^{-4} mg/kg/day. If the worker also experiences the concentrate spill, then his

Table 4-27--Lifetime risk of death resulting from everyday activities

Activity	Time to accumulate a one in a million risk of death[1/]	Lifetime risk per capita[2/]
Motor vehicle accident	1.5 days	1×10^{-2}
Falls	6 days	4×10^{-3}
Drowning	10 days	3×10^{-3}
Fires	13 days	2×10^{-3}
Firearms	36 days	7×10^{-4}
Electrocution	2 months	4×10^{-4}
Tornados	20 months	4×10^{-5}
Floods	20 months	4×10^{-5}
Lightning	2 years	3×10^{-5}
Animal bite or sting	4 years	2×10^{-5}
<u>Occupational Risks</u>		
General		
Manufacturing	4.5 days	2×10^{-3}
Trade	7 days	1×10^{-3}
Service and government	3.5 days	3×10^{-3}
Transport and public utilities	1 day	1×10^{-2}
Agriculture	15 hours	2×10^{-2}
Construction	14 hours	2×10^{-2}
Mining and quarrying	9 hours	3×10^{-2}
Specific		
Coal mining	14 hours	2×10^{-2}
Police duty	1.5 days	6×10^{-3}
Railroad employment	1.5 days	6×10^{-3}
Firefighting	11 hours	2×10^{-2}

1/Persons living in the United States.

2/Assuming 30 years at risk for occupational risks, 70 years at risk for other risks.

Source: Adapted from Crouch and Wilson (1982).

lifetime dose will be 5.1×10^{-3} mg/kg/day. An average lifetime dose for members of the public receiving exposures from multiple sources every 7 years will average 2.1×10^{-4} mg/kg/day.

Carbaryl is not a carcinogen, but it theoretically could be converted to the known carcinogen N-nitrosocarbaryl under acidic conditions in the stomach if nitrite is present. Consequently, cancer risks have been calculated for the public assuming that exposure is oral, and 1 percent of the weight of the ingested carbaryl is converted to N-nitrosocarbaryl. Several cancer potency figures were found in the literature for N-nitrosocarbaryl. They ranged from 0.057 (Lijinsky and Schmahl, 1978) to 7.6 $(mg/kg/day)^{-1}$ (Lijinsky and Taylor, 1976). The highest of these figures, 7.6 $(mg/kg/day)^{-1}$, will be used here. Under these assumptions, the maximum risk of cancer that could occur would be 1.6 chances in 100,000 for a member of the public with multiple dietary exposures every 7 years (see table 4-28).

The small formaldehyde component of Sevin XLR Plus would not add significantly to this cancer risk, based on EPA's estimate of formaldehyde's cancer potency (U.S. EPA, 1986d).

EPA (1986d) has estimated the risk of cancer for agricultural workers with a high exposure to pesticides containing formaldehyde as a preservative. Assuming a 40-year worklife, a concentration of 0.3 percent formaldehyde, and exposures from mixing, loading, and applying formaldehyde by boom sprayer (one application per year) and airblast equipment (4 applications per year), the lifetime cancer risk was estimated to be no greater than 1 in 1 million (1×10^{-6}). The concentration of formaldehyde in Sevin XLR Plus is about 0.1 percent,

Table 4-28--Maximum theoretical lifetime cancer risks for carbaryl

Exposure category	Lifetime cancer risk
Public (multiple exposures)1/	1.6×10^{-5}

1/Although carbaryl has not been shown to cause cancer, its conversion product, N-nitrosocarbaryl, is a potential carcinogen. In humans, N-nitrosocarbaryl can form only under the acidic conditions found in the stomach, so cancer risk is assumed for only oral ingestion (dietary) exposure to the public (and not workers).

or one-third of that assumed in EPA's exposure assessment. Therefore, the risk to workers of getting cancer from the formaldehyde constituent of Sevin XLR Plus is expected to be less than 1 in 1 million.

Diesel Oil. The acute toxicity of diesel oil is much less than that of carbaryl. The LD_{50} for diesel oil is 27 times greater than that for carbaryl. Data are not available to show the interaction of toxic effects of diesel oil and carbaryl; consequently, it is prudent to assume that the effects are additive. This is the approach recommended by EPA in "Guidelines for the Health Risk Assessment of Chemical Mixtures" (U.S. EPA, 1986e). However, even assuming dose additivity, the diesel oil component of the carbaryl/diesel oil mixture would not affect the carbaryl margin of safety by more than a few percent. This indicates that the toxic effects of the carbaryl/diesel oil mixture are likely to be caused predominantly by the carbaryl component. The greatest exposure to diesel oil that may occur under routine circumstances would result from eating quail from a sprayed area. In this case, the predicted dose, 7.66×10^{-2} mg/kg, is lower than the LD_{50} by a factor of more than 96,345.

An accidental spill of diesel oil onto a worker could produce a dose that is about 1/19 times the LD_{50}, if the worker does not change his clothes and wash. Severe skin irritation and even blistering may result.

Although diesel oil has not been shown to be a carcinogen, it is known to contain small amounts of substances that are known or suspected of being carcinogenic. Based on assumed concentrations of 28.5 ppm and 313 ppb for benzene and benzo(a)pyrene, respectively, the total cancer potency has been calculated as 4.9×10^{-6} $(mg/kg/day)^{-1}$. (See appendix A.)

Lifetime doses to workers after 30 years of employment are estimated to average 4.1×10^{-4} mg/kg per day. If the worker also experiences the spill, then his lifetime dose will be 2.1×10^{-2} mg/kg per day. An average lifetime dose for members of the public receiving exposures from multiple sources every 7 years will average 2.6×10^{-4} mg/kg per day.

Using these average lifetime doses and the potency given above in the linear model, the cancer risks shown in table 4-29 were calculated. The highest risk is to a worker who has experienced a spill along with his usual occupational exposure. The risk for this case is about 1 in 10 million. The highest risk to the public is about 1 in 800 million.

Table 4-29--Maximum theoretical lifetime cancer risks for diesel oil

Exposure category	Lifetime cancer risk
Worker (mixer/loader, 30 years)	2.0×10^{-9}
Worker, with spill of diesel oil	1.0×10^{-7}
Public (multiple exposures)	1.3×10^{-9}

Carbaryl Bait. Carbaryl bait will not produce significant dermal or inhalation exposures. Human dietary exposure from eating vegetables or meat also will be insignificant. Accidental exposure from drinking water is possible, if a water body is directly treated. Water concentrations would be at most equal to those from Sevin 4-Oil applied at the same rate of active ingredient per acre. Consequently, as shown by comparison with exposures calculated for Sevin 4-Oil, exposure via water directly treated with carbaryl bait will give doses much lower than the NOEL.

Acephate Spray. Under the routine scenario, margins of safety are 227 for mixer/loaders and 555 for pilots. A worker or member of the public receiving both dermal and inhalation doses of acephate at 500-feet downwind of a large spray block would receive a dose that is lower than the lowest NOEL with a margin of safety of 1,190 (see table 4-23). EPA used a safety factor of 100 in setting the provisional ADI. If members of the public eat grains soon after they are directly sprayed, they could receive a dose with a margin of safety of 87. If quail from a sprayed area are eaten, then the margin of safety would be 40. Exposures from eating either quail or grain are greater than the ADI (table 4-25). Multiple routes of exposure to the public could give a dose that is 16 times greater than the ADI, with a margin of safety of 6.2. Exposures of this magnitude are not likely to cause symptoms in most individuals, but they may cause some symptoms of cholinesterase inhibition in very sensitive individuals. Possible symptoms include headache, dizziness, and nausea.

The highest accidental exposures are for spraying of a leafy crop, with a margin of safety of 7.4. Other accidental exposures have a margin of safety of 15 or more. Jettisoning of acephate into a reservoir would produce a dose with a margin of safety of 81. See table 4-25 for a comparison of estimated

Table 4-30--Maximum theoretical lifetime cancer risks for acephate

Exposure category	Lifetime cancer risk
Worker (mixer/loader--30 years)	2.3×10^{-7}
Worker, with spill of mixture	4.5×10^{-6}
Public (multiple exposures)	3.8×10^{-7}

exposure doses and ADI levels. Accidental exposures exceeding the ADI would include cases of accidental spraying, jettison into a reservoir, and concentrate spills.

An accidental spill of acephate mixture onto a worker could produce a dose that is 50 times greater than the NOEL. However, this dose is still only 1.4 percent of the oral LD_{50}. This degree of exposure is likely to cause moderate symptoms of cholinesterase inhibition. These symptoms, which are reversible, include vomiting, diarrhea, weakness, dizziness, blurred vision, and sweating.

Lifetime doses to workers (mixer/loaders) after 30 years of employment are estimated to average 2.6×10^{-5} mg/kg/day. If the worker also experiences the spill, then his lifetime dose will be 4.9×10^{-4} mg/kg/day. An average lifetime dose for members of the public receiving exposures from multiple sources every 7 years will average 4.2×10^{-5} mg/kg/day.

EPA has classified acephate as a possible carcinogen (Group C) with an estimated cancer potency of 9.1×10^{-3} $(mg/kg/day)^{-1}$ (U.S. EPA, 1985). Combining this estimate of cancer potency with the lifetime doses given above, the cancer risks shown in table 4-30 were calculated. The highest risk is to the mixer/loader who has experienced a spill along with his usual occupational exposure. In this case, the risk is 4.5 in 1 million. The highest risk to the public is 3.8 out of 10 million.

Methamidophos. The margins of safety for exposure to methamidophos from applications of acephate are in table 4-24. For most of the routes of exposure, the margins of safety are in the same range as that for acephate. An exception to this is the margin of safety of 9.5 for eating quail (compared to a margin of safety of 40 for acephate). The dose of methamidophos from eating quail is relatively higher because these birds

have a high proportion of grasshoppers in their diet and grasshoppers have been shown to convert acephate to methamidophos at a high rate (29 percent). (See appendix B.)

An accidental spill of concentrate with a methamidophos exposure to a worker of 60 times greater than the NOEL is likely to cause symptoms of cholinesterase inhibition, including vomiting, diarrhea, weakness, dizziness, blurred vision, and sweating.

Impacts of Multiple Chemical Applications

Doses to humans from a repeated application of carbaryl or malathion 4 weeks after the initial application would not result in effects different from those described for a single application. Both chemicals have rapid degradation rates in plants and water and would have insignificant residues remaining after 4 weeks. The half-lives for malathion are 5.2 days in plants and 1.5 days in water. After 28 days, only 2.4×10^{-2} of the initial residue would remain on vegetation and only 2.4×10^{-6} of the initial concentration would remain in water.

The half-lives for carbaryl are 3 to 7 days in plants and 1 to 5 days in water. Only 6.25×10^{-2} of the initial amount would remain in plants after 4 weeks, and only 6.57×10^{-2} of the initial amount in water would remain.

Because of label restrictions, acephate would not be reapplied on rangelands within the same season.

Biological Controls

Although Nosema can infect many species of grasshoppers and several species of crickets, it has not infected other species of insects or any species of warm-blooded animals (Maugh, 1981). No adverse effects are known for humans.

Impacts of Grasshopper Control Alternatives

No Action

Chemicals would not be used by APHIS under this alternative, so the impacts on human health discussed in the previous sections would not occur. In the long term, however, severe infestations could cause regional declines in rangeland productivity and livestock production, which would have adverse effects on the human communities that depend on them.

Chemical Control Alternative

The impacts of chemical controls on human health have been described in the risk analysis above. In terms of acute toxic effects, malathion is the least toxic. In terms of long-term effects, such as cancer, carbaryl appears to have the lowest risk.

IPM Alternative

This alternative combines the benefits of control methods with lower risk to human health, such as the use of Nosema where it is feasible, with the advantages to the livestock industry of quick response to heavy infestations where that response is necessary. Impacts overall on human health should be somewhat lower than those under the chemical control alternative.

AIR QUALITY IMPACTS

Impacts of Grasshopper Control Methods

The potential impacts of grasshopper control activities on air quality include slight increases in fugitive dust from wind erosion of disturbed soils; slight increases in concentrations of criteria pollutants from the internal combustion engines of the vehicles, airplanes, and machinery used in grasshopper control operations; and increases in ozone concentrations from the volatization of photochemically reactive organic compounds in pesticides. In addition, photochemical smog may be produced from the degradation of diesel oil used as a carrier when exposed to sunlight.

Criteria pollutants--pollutants for which maximum allowable emission levels and concentrations are enforced by State air control agencies--will be produced by fuel combustion in airplanes, vehicles, and machinery used in grasshopper control activities. The amounts of these pollutants should have a negligible effect on air quality except on a localized and temporary basis.

Increases in ozone concentrations from the volatilization of pesticides and carriers are also expected to be negligible. All three chemicals have very low vapor pressures and are essentially nonvolatile.

Carbaryl is the only chemical alternative under consideration that uses a petroleum carrier--diesel oil--for application. Diesel oil has a relatively high vapor pressure and is relatively volatile. When exposed to sunlight, the alkenes in diesel oil rapidly undergo photochemical degradation and react with oxygen, ozone, and nitrogen oxides to form photochemical smog. The areas where photochemical smog has the potential to affect the air quality are highly urbanized areas or areas with polluting industries. These include the urban areas of southern California and the smeltering industries of southeastern Arizona and southwestern New Mexico. However, no smog impacts are expected because the grasshopper control areas are in the very sparsely populated rangelands, and the amount of photochemical smog occurring from diesel oil used as a carrier is expected to be negligible because of the small amounts used in grasshopper control activities (approximately 4 ounces per acre).

Impacts of Grasshopper Control Alternatives

No Action

Air quality impacts under the no action alternative would primarily be dust impacts from erosion caused by vegetation losses under severe outbreak conditions. The difference among alternatives in terms of air quality, however, is likely to be negligible.

Chemical Control Alternative

Impacts on air quality under the chemical control alternative would be the highest of the three alternatives because of the use of insecticides, spray planes, and ground vehicles.

IPM Alternative

Air quality impacts should be lower under this alternative because the overall use of chemical pesticides in a given year would be reduced.

NOISE IMPACTS

Noise levels from grasshopper control activities will be greatest when aircraft are used to apply pesticides. Vehicles used to transport support personnel, as well as equipment and machinery used in cultural/mechanical methods, also will increase noise levels.

Residents living in remote or rural areas may find any of these noises objectionable. However, the noises would be temporary and localized in all cases. In addition, the use of such equipment would not be negatively perceived by most residents of agricultural and rangeland areas who are acclimated to the sounds of farm machinery and agricultural aircraft.

Noise from any of these activities could cause wildlife to leave treatment and adjacent areas temporarily but should cause no adverse effects to wildlife because of the short duration of the noise and its infrequent occurrence in a given area.

CULTURAL RESOURCES

As described in chapter 3, many of the buildings, structures, objects, sites, districts, and archaeological resources listed on the National Register of Historic Places are located in the western States. Most of these places are located on Federal and State forests, parks, and recreational areas, Indian lands, and public lands. APHIS will consider grasshopper control programs on these lands only when requested to do so by the responsible cooperating land manager. In addition, APHIS is committed to working with the responsible land manager prior to the start of any control program. It is highly unlikely that any control operation would adversely affect cultural or historic resources.

Pesticide formulations that use diesel oil as a carrier (Sevin 4-Oil) may affect archaeological resources. Radiocarbon dating techniques, used to determine the approximate age of artifacts, are based on the fact that organisms accumulate carbon during their lifespan. The carbon breaks down at a certain rate after the death of the organism and the techniques measure the ratio of elements remaining in the artifact. The application of pesticides alone affects the surface of the artifact, but it can be removed in the laboratory. Oil products, however, seep below the surface into the subsurface portions of the artifact. Archaeologists alerted to the fact that an artifact may have been contaminated can use organic solvents to remove the oil but it may be difficult to remove all of the solvents. The solvent itself may contain carbon 14 and can interfere with the dating process. It is extremely unlikely that effects of this kind would occur because of the very small amounts of oil used per acre and because any artifacts that may be in an area are likely to be protected by soil or plant cover.

It is possible that grasshopper control activities could have an impact on native plants that are collected by native American Indians for use as food or medicine, in dyes and weaving, or for use in other cultural activities. Impacts on vegetation are discussed earlier in this chapter. The chemical alternatives are not toxic to vegetation when applied at rates indicated on the label.

VISUAL RESOURCES

The landscapes of the West possess a broad range of visual resources. Many of the Federal and State lands are valued for their high scenic quality and aesthetic appeal. It is possible that grasshopper control programs would affect the visual resources of these areas.

Chemical spraying will have the most impact. However, the visual effects of broadcast application are localized and temporary, and vegetation impacts would be minimal. The impacts of pesticide drift and mitigating measures to reduce drift are discussed earlier in this chapter. People in nearby communities might see the aircraft and vehicles used in control activities and consider these to be a visual intrusion. However, it is expected that most people in rangeland areas are accustomed to the sight of farm machinery and agricultural aircraft.

SOCIOECONOMIC EFFECTS

Economic Impacts of Grasshopper Infestation

Table 4-31 shows the impact of grasshopper forage destruction on the forage production and the average stocking rates in each ecoregion in terms of animal unit months (AUM's). The potential forage destruction could have serious impacts on

Table 4-31--Impact of grasshopper forage destruction on stocking rates

	Tall-grass prairie	Short-grass prairie	Plateau	Desert	Great Basin	California Grasslands	Mountains
Average annual forage production (lb per acre)	2730	1443	278	488	706	2064	1775
AUM equivalent	3.6	1.9	0.37	0.65	0.94	2.7	2.3
Average stocking rate (AUM per acre)	0.78	0.29	0.06	0.05	0.09	1.05	0.22
Forage destruction (AUM equivalent)							
8 grasshoppers/square yard	0.12	0.12	0.12	0.12	0.12	0.12	0.12
16 grasshoppers/square yard	0.25	0.25	0.25	0.25	0.25	0.25	0.25
32 grasshoppers/square yard	0.50	0.50	0.50	0.50	0.50	0.50	0.50

Source: Adapted from Hewitt and Onsager (1983).

rangeland grazing in several ecoregions, particularly those with low annual forage production and high infestation densities. Infestation densities of 30 to 40 per square yard, which are not uncommon, could severely affect the short-grass, mountains, plateau, desert, and Great Basin ecoregions. It has been estimated that rangeland grasshoppers annually destroy (consume and waste) approximately 23 percent of available rangeland. This represents a loss of about $393 million per year assuming the vegetation could otherwise be used by livestock (Hewitt and Onsager, 1983).

Range and nonrange grazing are crucial in the domestic production of beef and lamb, supplying approximately 64 percent of the feed consumed by cattle and about 79 percent of the feed consumed by sheep. In addition, range grazing is an important part of the economy for many localities and regions in the 17 western States.

The demand for range grazing is based on consumer demand for livestock products, such as meat, hides, wool, tallow, insulin, and other byproducts. The two main factors affecting the demand for range grazing are the demand for meat and the change in relative prices of feed elements.

The demand for meat, or per capita meat consumption, is a function of many variables including disposable income and the availability of meat substitutes. Historically, rising per capita incomes have led to increased consumption of beef and fresh fruit and decreased consumption of milk, eggs, potatoes, and grain products. This in turn has led to increased demand for grazing and harvested roughage. Personal disposable income has shown a steady increase since 1970 and is projected to continue to increase. Per capita consumption of meat, while decreasing from a high in the mid-1970's, has remained stable in the 1980's.

The demand for range grazing is also influenced by the relative prices and costs of production of other feed sources. Because livestock can be raised effectively on grain or forage or combinations of the two, anything that substantially affects the prices of either will have an impact on the livestock production process. If feed grain prices are relatively low, grain feeding will replace forage in the livestock production process. High grain prices will encourage producers to finish animals for slaughter with less feeding of grain and may ultimately increase the amount of forage from grazing in the livestock diet. In addition, consumer preferences influence the proportion of grain and forage in livestock diets. An increased grain diet produces marbled beef, whereas more forage in the diet produces a leaner beef.

The amount of range available to livestock for grazing is important to the national livestock industry as well as to many regional and local economies. The chemical control and IPM alternatives that control grasshopper infestation and preserve rangeland forage for consumption by livestock will have beneficial economic impacts on local communities. On the other hand, the no action alternative would be likely to have significant impacts for individual ranchers and local economies. If ranchers do not choose to control infestations, or if they cannot change their ranch management practices, such as providing supplemental feed or moving the herd to uninfested rangeland, they could be faced with severe economic loss.

Cost Analysis of Grasshopper Control Alternatives

Overview

This section discusses the relative costs of alternative grasshopper control methods and relates those costs to the program goals of responding to the needs of livestock producers in reducing or preventing economically significant grasshopper infestations while maintaining the quality of the rangeland environment. In some areas, it may not be economical to treat for grasshopper infestations because of the low forage production and low stocking rates. In addition, it may not be economical to treat grasshopper infestations in areas where forage production is relatively high. In these areas, grasshopper forage destruction would not affect the stocking rates as severely as in other areas because the competition between livestock and grasshoppers for forage is not as great. Because APHIS' involvement in grasshopper control is initiated by landowner or other agency requests, it is understood that ranchers and range management agencies have made decisions concerning the need for control, and that they have weighed the costs of available control methods and some of the ranch management strategies discussed below as part of that decision.

Summary of the Mann Model

Mann et al. (1983) used a series of computer models to perform an economic analysis of alternative grasshopper control strategies. Their principal goal was to evaluate Nosema on bran bait as a control alternative, but their analysis encompassed all the currently available control measures, including conventional pesticide sprays and carbaryl on bran bait. They also examined the use of various ranch management practices, including feeding hay, selling cattle early, reducing the stocking rate, and relocating the herd to other pasture, that could offset the effects of a grasshopper infestation on cattle weight gains. (These ranch management practices are non-APHIS-funded practices conducted by individual ranchers.) Each of the models was quite complex and produced a large amount of output. The models and their respective numerical outputs

will not be presented here, but the models will be briefly described and the results and conclusions summarized.

A grasshopper population dynamics model was used to determine the amount and types of range forage lost per day. Stocking rate models were used to estimate the impact of increased stocking rate, in terms of loss of forage to grasshoppers, on cattle weight gains, calf crop, and calf birth weight, and in turn on rancher revenues. A cattle simulation model examined in greater detail the competition between livestock and grasshoppers for range forage. Finally, a linear programming (LP) model of a ranch operation examined optimal ranch resource allocation in response to a grasshopper infestation on a single rangeland pasture. The ranch model represented a smaller than average ranch in Sheridan, Wyoming, and it is used here as a case study of a ranch that participates in APHIS' cooperative grasshopper management program.

The modeling results showed that ranchers were able to alleviate income losses under grasshopper infestation through changes in management practices. The stocking rate and cattle simulation models indicated that feeding hay in the fall, increased overwinter feeding, and early marketing of cattle could provide some economic relief from grasshopper infestations. The linear programming models indicated which changes in feeding and stocking patterns would lead to an optimum resource allocation for the entire ranch. Relocating cattle to other available pasture appeared to be most economical in some situations.

However, ranch operations often do not have the option for short-run variations in feeding and selling practices in response to grasshopper infestations. Their flexibility may be limited by contractual arrangements, lead time needed, and uncertainty in estimating grasshopper populations and subsequent impacts. In these instances, ranchers may choose to participate in APHIS' cooperative grasshopper control program. The relative costs of the alternative control methods are addressed below.

Relative Costs of Control Alternatives

The cost information for alternative control methods used in the Mann et al. (1983) economic analysis is listed in table 4-32. Grasshopper control costs were the sum of three components: material, support, and application costs. Material costs were the costs of the pest control formulation applied, whether insecticides or Nosema. Support costs included travel and labor costs associated with control incurred by program personnel. Application costs referred to the costs of contracting an applicator and aircraft. The insecticide (material) cost was taken from 28 control operations in Wyoming from 1972 to 1980. The bran costs are from field

Table 4-32--Costs per acre used in Mann's modeling of grasshopper control alternatives
(in dollars)

Chemical	Material	Support	Application	Total
Malathion	0.98	0.16	0.82	1.96
Carbaryl	1.57	0.16	0.82	2.55
Carbaryl Bran	0.28[1]	--[2]	1.68	1.96
Nosema Bran	1.55[3]	--[2]	1.68	3.23

[1]Includes $.15/acre for the bran and $.13/acre for the carbaryl.
[2]Support costs included in application costs.
[3]Includes $.15/acre for the bran and $1.40/acre for the Nosema.

Table 4-33--Current cost data for grasshopper control analysis[1]
(dollars per acre)

Chemical	Material	Support	Application	Total
Malathion	1.06	0.32	1.09	2.47
Carbaryl	1.89	0.28	1.50	3.67
Acephate	0.69	0.30	1.30	2.29
Carbaryl Bran	0.13 0.15	0.30	1.90	2.48
Nosema Bran	1.40 0.15	0.30	1.90	3.75

[1]Averages determined for APHIS control programs, May-July 1986, or adapted from Mann et al. (1983).

trials in Wyoming and Arizona, and the Nosema costs from a survey of Nosema producers.

Table 4-33 lists costs for the current APHIS grasshopper management program based primarily on data from APHIS on

control operations conducted from May to July 1986. The current Nosema cost was provided by the only commercial producer of Nosema (Evans, personal communication, 1986).

Examination of the Mann modeling costs and of the current costs shows that material costs have risen only slightly, while support and application costs have increased substantially from 1980 to the current year. The relative costs of the control methods, however, have remained the same. On a per-acre basis, malathion and carbaryl bait are the least costly. Carbaryl spray is more costly. Nosema is the most expensive. Acephate was not analyzed in the Mann report, but current projections are that it would be comparable in cost to malathion spray and carbaryl bait treatments.

Other Considerations Affecting Cost-effectiveness

The prediliction or affinity of grasshopper species for the bran in Nosema and carbaryl bait control methods also affects the cost-effectiveness of these methods. Some grasshopper species will readily eat the wheat bran bait while others will eat little, if any, of it. Thus, bran bait generally will more effectively control the grasshopper species complexes containing the species that will eat the bran. (However, even species that do not eat bran can contract the disease from species that do.)

The results of Mann et al. demonstrated that conventional insecticide control provides immediate reductions in densities, while Nosema takes longer to achieve its full potential. They concluded that it was not reasonable to expect Nosema to provide adequate control in situations where immediate relief from an infestation is needed. They suggested that the role of Nosema in a control program should be considered preventive rather than reactive (like the use of chemical insecticides) and should not be used where the goal is immediate relief from a grasshopper infestation. However, as discussed in chapter 2, Nosema infections have been verified the year following its introduction. Thus, grasshopper population preference for the bran, early introduction, and survival rates in following years proved to be principal factors affecting the cost-effectiveness of Nosema. Additionally, it can be assumed that as Nosema is used more, its production costs will decrease.

Application timing appears to be the critical factor affecting the cost-effectiveness of conventional insectide use as well. Treatment that is too early would miss grasshoppers not already hatched. Treatment that is too late would fail to reduce forage loss in the current year and would not prevent egg laying, which could result in reinfestation the following year. As discussed in chapter 2, where all other factors are equal, carbaryl would be most effective in early treatments (third

instar) because of its residual action but lower initial kill. Malathion would be most effective in late season (fifth instar) because of its high initial kill rate but low residual toxicity. Acephate would be appropriate for mid- to late-season programs.

Results of the Mann et al. (1983) modeling also indicated that well-timed conventional insecticide control provided larger economic returns and was more cost-effective than the Nosema or carbaryl bran bait alternatives. Unless the costs of bran bait application and Nosema are substantially reduced, conventional control methods will likely remain more economical.

APHIS and its cooperators, however, consider factors other than monetary cost in choosing among alternative control methods. Because the potential environmental impact of Nosema or carbaryl bait controls is negligible compared to conventional insecticides, they may be preferable where susceptible species are present and environmental concerns (the presence of endangered species, fish habitats, or game bird populations) restrict the use of conventional insecticides. Also, the use of Nosema or carbaryl bran baits may allow a control block to be completed where one landowner's fears of environmental damage are preventing conventional control. This situation is likely to occur in more populated areas where more landowners may be required to form a block. Other ecological and sociological considerations affecting the choice of a method are discussed in chapter 2.

Effects of Control Alternatives on Socioeconomic Groups

Sociological Impacts on the General Public

The public scoping process for this EIS revealed that while the various social groups tend to view the control alternatives in different ways, most support APHIS' efforts to control grasshopper infestation. Some people are opposed to the broadscale application of pesticides into the human environment; however, even these people acknowledge the damage that severe grasshopper infestation can cause. Many of these people support an integrated pest management approach.

Traditionally, ranchers have taken a reactive approach by requesting assistance when grasshopper populations have reached economically important levels. The success of an integrated pest management approach would depend in part on the willingness of State cooperators and private ranchers to invest in a preventive approach toward grasshopper control and one that does not rely solely on the use of chemicals.

Impacts on Livestock Owners

Livestock owners constitute the largest social group of the interested public who are likely to be affected by grasshopper

control programs. For the most part, ranchers, and especially residents of historic "hotspots" of grasshopper outbreaks, support the APHIS grasshopper control program. APHIS will treat private lands only when requested to do so. APHIS will avoid any residence whose owner objects to treatment on his or her property, except when mandated under State law.

Impacts on Vehicle Owners Near Spray Areas

Malathion is known to damage automobile paints. There is some possibility that malathion used in grasshopper control could damage the paint finish on automobiles in or downwind of a spray site because of drift. Any damage of this kind is likely to be negligible compared to the normal wear on a paint finish from windborne dust and road debris associated with road travel in rangeland areas.

Impacts on Users of Public Lands

The users of the Nation's public lands, Federal and State forests, parks, wilderness, and recreational areas are not likely to be adversely affected by grasshopper control programs. APHIS is committed to working with the land managers of these sensitive areas and with the public before any control program begins. Operational procedures prevent the spraying of ULV insecticides within 500 feet of recreational areas, such as campgrounds, where members of the public may be exposed.

Impacts on Apiarists

All three chemical alternatives are highly toxic to honey bees. Individual producers can face major losses if they do not follow operational procedures such as moving or otherwise protecting hives during control treatment. APHIS is committed to notifying the public and registered apiarists within the State at the beginning of treatment season and before control programs begin. Other operational procedures and mitigation measures designed to protect bees are described in detail in chapter 2. Nosema would not adversely affect honey bees (Menapace et al., 1978).

Impacts on Alfalfa Cultivators

Several species of bees, including alkali and leafcutter bees, are routinely used in farming practices to increase the yield of alfalfa seeds. The chemical control and IPM alternatives have the potential to affect the cultivation of alfalfa as these bees are susceptible to the chemical insecticides and cannot be moved during the summer. Nosema would not adversely affect alfalfa cultivators.

Alfalfa is cultivated in the tall-grass, plateau, and California grassland ecoregions. APHIS is committed to the operational procedures that are described in detail in table 2-1. If treatments are planned within 4 miles of areas where alkali or leafcutter bees are being used, procedures include the use of spray samplers and monitoring of wind conditions and other drift factors. ULV sprays will not be applied near these areas when damaging drift would occur.

OTHER ENVIRONMENTAL EFFECTS

Overview

In the preceding sections of this chapter, analysis and discussion focused on the potentially significant environmental consequences of each alternative grasshopper control method. Individual resource element categories, such as water, soil, and wildlife, were considered separately to facilitate the discussion on environmental effects. The effects were described from a programmatic viewpoint. Any future analyses that might be required will focus on issues relevant to the specific cooperative program under consideration.

In accordance with the Council on Environmental Quality (CEQ) regulations for implementing the National Environmental Policy Act, other environmental effects are addressed in this section. These include cumulative and synergistic environmental effects; adverse environmental effects that cannot be avoided; the relationship between short-term uses of the environment and the maintenance and enhancement of long-term productivity; irreversible and irretrievable commitment of resources; possible conflicts between the proposed action and the objectives of Federal, State, and local agencies; and energy requirements.

Cumulative Effects

According to the CEQ regulations (40 CFR 1508.7), "cumulative impact" is the impact on the environment that results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (Federal or non-Federal) or what person undertakes such actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. Two types of cumulative impacts apply to the actions covered in this EIS.

First, there are the geographically cumulative or programmatic effects of APHIS grasshopper control activities across the 17 western States and Alaska. The area that is potentially affected by all APHIS grasshopper control activities is conservatively estimated at approximately 70 million acres over the next 5 years, based on 1985 treatment acreage.

Although residues are not expected to persist within the environment from year to year, the two to three treatments

within 1 year projected for some rangelands adjacent to croplands may cause temporary accumulation of pesticides in localized areas. However, these localized effects should not pose a threat to the environment. Control programs are generally not required at intervals of less than 7 years after initial treatment.

As was discussed earlier in this chapter, grasshopper control activities may have local impacts on wildlife, such as ChE depression and resulting behavioral changes, fatalities, egg contamination, and loss of food supply leading to reduced survival and/or reproductive success. However, because less than 1 percent of the total western rangeland acreage is likely to be sprayed in any one season, only a fraction of the total range of most wildlife species would be affected. Local reductions in food supply and other effects causing lowered survival and reproductive success therefore should not constitute a significant threat to the species throughout its overall range. The same would pertain to local populations affected by multiple chemical applications within limited areas. It is therefore unlikely that significant cumulative impacts will occur across the western States or Alaska on wildlife populations from APHIS grasshopper control activities.

A second category of cumulative impacts is the incremental impacts over time of APHIS-funded grasshopper control actions on any given land area in conjunction with those of other agencies or groups or of other APHIS programs. The only other APHIS programs conducted in the areas where APHIS grasshopper treatments occur are High Plains boll weevil treatments in Texas, which use malathion; and APHIS weed control programs conducted in Clearwater County, Idaho, which use picloram and dicamba. These programs occur before or after grasshopper treatment in the same areas.

The maximum amount of the insecticides that would conceivably be used by APHIS for grasshopper control could constitute up to 17 percent of the total amounts of these three chemicals used throughout the West. Manufacturers data submitted to EPA indicate that in the 17 western States, an average of 10 to 12 million pounds of carbaryl, 9 to 11 million pounds of malathion, and 3 to 5 million pounds of acephate are used annually on private and public lands. Assuming the average 2,049,000 acres treated annually for grasshopper control were sprayed exclusively with each of the insecticides, the amount of carbaryl, malathion, or acephate used could be up to 11 to 13 percent, 14 to 17 percent, and 5 to 8 percent, respectively, of total usage of each of the three insecticides in the West.

Individual farmers and large agricultural operations repeatedly use insecticides, including malathion, carbaryl,

and acephate, on croplands that are adjacent to rangelands, thereby increasing the chance of treatment overlap resulting from drift and runoff. For instance, spray drift may deposit up to 100 percent of the onsite-intended applied level of chemical 10 m (33 ft) from the treatment area and up to 7.5 percent 152 m (500 ft) from the treatment area. (Refer to the spray drift modeling section in appendix B.) Some overlap could, therefore, occur between treatment plots and adjacent croplands controlled by individual farmers. In addition, each APHIS treatment plot may contain up to 20 percent cropland, thus allowing for the possibility of 100 percent treatment overlap within these areas.

Timber- and paper-producing corporations, ranchers, public utilities, States, and counties also use insecticides to improve timber production, to enhance range management, to protect ornamental and shade trees, and to suppress pest insects in public recreation areas. Private programs thus may overlap with grasshopper treatment areas. For example, the black grassbug control effort in New Mexico, Arizona, and Utah uses 0.1 to 0.5 lb a.i./acre malathion on high-elevation crested wheatgrass fields ranging in size from 300 to 150,000 acres. Because control is required earlier in the season for black grassbugs than for grasshoppers, the possibility exists for two spray treatments to occur within the same area in the same year.

Although most Forest Service and BLM projects should not increase the cumulative effects of grasshopper control because of differing vegetative types, regions, or control needs (for example, herbicides instead of insecticides), possible overlap with programs such as western spruce budworm control could occur where treatment plots are adjacent to rangelands.

Thus, these insecticides already exist in the environment at some background concentration, and the use of the three insecticides during grasshopper control activities could increase the ambient concentration. APHIS guidance for preparing site-specific environmental assessments requires the officer-in-charge to identify whether other pesticide programs have occurred in a proposed treatment area during the current or previous season (when reliable information is available). APHIS conducts pretreatment sampling of soil, water, and vegetation to establish baseline levels of the insecticides proposed for use. In general, background concentrations of the three insecticides in surface and ground water and in air would be expected to be minimal (except in localized areas for short periods of time) because of the relatively rapid degradation of the insecticides in most situations. Half-lives of malathion in the soil range from 0.5 days in moist, organic soils (Curley and Donohue, 1986) to 7.5 to 11 days in low organic content soils (Gibson and Burns, 1977). Carbaryl

in soil has a half-life of 8 days (Johnson and Stansbury, 1965) and, depending on soil type, acephate has a half-life of 0.5 to 6 days (USDA, 1976). (Refer to the environmental fate section in appendix B for a more detailed discussion of the persistence of these three chemicals in the environment.)

Data gathered by the Food and Drug Administration (Gunderson, FDA, personal communication, as cited in USDA, FS/APHIS, 1985) show that high accumulations of residues of carbaryl and acephate have not occurred from eating meats, fruits, and vegetables produced in areas treated with these insecticides.

Based on the analyses presented in this chapter and the wide dispersal of the affected environment, significant programmatic effects on human health or elements of the natural environment from APHIS' cooperative control program are unlikely.

Synergistic Effects

Synergistic effects occur when the combined effects of two or more chemicals are greater than the sum of the effects of the individual chemicals or are different from the effects of any of the individual chemicals. There is a possibility that an insecticide applied during grasshopper control could interact with other chemicals already in the environment to cause synergistic effects.

There are relatively little data available concerning the effects of the insecticides under consideration, in combination with other chemicals, on animals and humans. Statham and Lech (1975) reported that rainbow trout exposed to a sublethal concentration (1 mg/L) of carbaryl increased the acute toxicity of 2,4-D n-butyl ester (2,4-DB) and rotenone. The LC_{50} of 2,4-DB decreased from 30.0 to 11.2 mg/L. Carbaryl apparently increased the uptake of 2,4-DB by trout. As the authors noted, however, these concentrations are not likely to be found in the aquatic environment under normal circumstances.

A synergistic effect of malathion (13.5 mg/L) and its basic hydrolysis products was found in the fathead minnow (Bender, 1969). Although this could cause concern with respect to multiple applications within the same season, the elimination of bodies of water from treatment and the low dosage rates should reduce the chance of this effect occurring.

The joint actions of malathion and EPN, and malathion and trichlorofon, were found to be synergistic to both Japanese quail and ring-necked pheasant chicks at lethal concentrations (Kreitzer and Spann, 1974). Combinations of EPN and malathion also lead to increased toxicity and AChE inhibition in dogs at doses as low as 2 and 10 mg/kg, which are one-sixth and one-thirty-sixth of their lethal doses (Karczmar et al., 1962). Malathion in conjunction with carbaryl was synergistic in rats following multiple administrations of 50/50 mg/kg doses

(Abdel-Rahman et al., 1985), and the combination of malathion, chlordane, and parathion (Keplinger and Deichmann, 1967), as well as malathion and disulfoton (Costa and Murphy, 1983), were synergistic in mice at acute toxic levels.

Although several other treatment programs are conducted on or adjacent to rangelands (such as rangeland caterpillar control that uses permethrin, fire ant control that uses amdro, and various weed control programs that commonly use 2,4-D) the use of pesticides known to cause synergistic effects when combined with grasshopper control pesticides is not widespread throughout rangelands.

The dose or concentration of any chemical determines the probability and rate, and often the magnitude, of any chemical reaction. For this reason, the concentration of a pesticide in the environment or in an individual is important in considering synergistic effects. For very small concentrations, a multiplicative or synergistic effect would not be expected (Crouch et al., 1983). Only very low and very short-lived doses could be expected to result from the use of insecticides in grasshopper control (refer to exposure and risk analyses in chapter 4 and appendix B). Therefore, although synergistic effects were reported for lethal doses of pesticides, no synergistic interactions are expected to occur on rangelands.

Although synergistic effects are not expected to occur at the projected low levels in the environment, workers who routinely conduct spray operations for a variety of pesticides may be at a higher risk. Workers may come into direct contact not only with grasshopper control insecticides and other rangeland pesticides, but also with chemicals used in agricultural, forestry, industrial, and other control programs. This would result in workers being exposed to higher concentrations of a wider variety of pesticides than most humans.

Adverse Environmental Effects that Cannot be Avoided

The killing of nontarget insect species and secondary impacts on wildlife species that depend on grasshoppers and nontarget insects for food are unavoidable adverse impacts of using chemicals in grasshopper control. The routine and accidental analyses presented in this chapter have been conducted to describe the most likely adverse effects. Adherence to the mitigation measures and operational features built into the preferred alternative should minimize the potential for any of these adverse effects.

Short-Term Uses Versus Long-Term Productivity

The relationship between short-term uses of man's environment and the maintenance of long-term productivity depends upon site-specific information. No grasshopper control activities are expected to result in long-term effects on rangeland productivity.

Applications of the insecticides in accordance with label instructions will ensure that the long-term productivity of the soil will not be disturbed. All three of the proposed chemical insecticides have been used extensively in agriculture with no evidence of impairment of long-term productivity. The preferred alternative of IPM allows APHIS to choose from a full range of chemical and nonchemical control methods based on the sensitivities of each site.

Conflicts with Plans of Federal, State, or Local Agencies

As stated in the operational procedures in table 2-1, control personnel will follow all applicable Federal, State, and local environmental laws and regulations in conducting grasshopper control operations. For example, grasshopper control operations would comply, as necessary, with local noise control ordinances, land-use plans, State and local water-quality plans per Section 313(a) of the Clean Water Act, State Implementation Plans prepared under the Clean Air Act, and State requirements for the handling and use of pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act. Grasshopper treatments on Federal, State, or private lands are conducted in cooperation with the Federal and State land managers and with the private landowner. Thus, potential conflicts should be avoided.

Irreversible and Irretrievable Commitment of Resources

The time, manpower, and money spent on grasshopper control activities represent an irreversible and irretrievable commitment of Government resources. In addition, the amount of petroleum products, bran bait, and pesticides used in grasshopper control activities represent an irreversible and irretrievable commitment of resources.

Energy Requirements

Fuel use in the control of grasshoppers involves the consumption of fuels in the operation of aircraft and equipment during treatment and in the transport of personnel, equipment, and materials to a treatment area. In addition, fuel use also includes the use of diesel oil as a carrier for pesticide application. The principal fuels consumed are petroleum products such as aviation fuel, gasoline, and diesel fuel.

The relative energy efficiency of the different grasshopper control methods varies on a case-by-case basis. In general, aerial broadcast application of pesticides is the most efficient, especially over large control blocks.

Chapter 5
Applicable Envionmental Regulations and Consultation Requirements

OVERVIEW

Numerous statutes and regulations designed to protect environmental quality have been promulgated by the Federal Government and by many States. These statutes and regulations impose various requirements on individuals and agencies proposing actions that may have a significant environmental impact. APHIS recognizes the importance of compliance with Federal, State, and local laws designed to protect environmental quality. This chapter describes some of the Federal and State environmental laws that are potentially applicable to APHIS operations. The operational procedures and mitigation measures described in this programmatic EIS are designed to ensure that all cooperative control activities are conducted in compliance with applicable Federal laws. Site-specific procedures for complying with applicable State and local laws in conducting control operations will be developed at the appropriate level of analysis for specific treatments.

ENVIRONMENTAL POLICY REQUIREMENTS

In 1969, the National Environmental Policy Act (NEPA) (42 U.S.C. 4321 et seq.) established policies and procedures for ensuring that Federal actions are consistent with the Nation's environmental quality objectives. NEPA requires that Federal agencies use a "systematic, interdisciplinary approach" to assess the impact of "major Federal actions significantly affecting the quality of the human environment." Regulations promulgated by the Council on Environmental Quality (CEQ) provide detailed requirements for implementing NEPA (40 CFR 1500-1508). Furthermore, Federal agencies, including the Departments of the Interior and Agriculture, have established their own supplemental implementing procedures, as required by the CEQ regulations (Interior Departmental Manual Part 516 and 7 CFR 1b, respectively). APHIS' guidelines provide further detail for implementing NEPA (44 FR 50318-50384, and 44 FR 51272-51274, August 28, 1979).

Several States have also enacted State environmental policy acts (SEPA's) and have promulgated implementing regulations. These acts typically impose NEPA-like requirements on State agencies.

This EIS documents the results of an environmental analysis conducted to determine which methods would be available to APHIS for controlling populations of grasshoppers and Mormon crickets beginning in 1987. It may be used as a broad, comprehensive background source on which any necessary subsequent environmental analyses can be tiered, in accordance with CEQ's

procedures for implementing NEPA (40 CFR 1502.20 and 1508.28). Tiering eliminates repetitive discussions of the same issues and allows consideration of the actual issues that are ripe for decision at each level of environmental review.

Future environmental analyses of APHIS-funded cooperative control activities will be conducted at the appropriate level and will focus on resources that are unique to the particular activity, as necessary. These environmental analyses will be prepared by the Bureau of Land Management (BLM) or the Forest Service for treatments planned on lands under their jurisdiction in accordance with memoranda of understanding with these agencies. In the case of private or State lands, APHIS is responsible for the preparation of site-specific environmental assessments. However, cooperative agreements are negotiated with each State, and the State may assume responsibility for site-specific environmental assessments as part of its agreement.

APHIS has recently developed guidance on preparing environmental assessments (EA's). The guidance requires consideration of site-specific grasshopper control alternatives and their potential impacts. The EA's will focus on any unique resources or impacts not represented in this programmatic EIS. For example, the EA will identify and develop protection measures for limited range or unstable wildlife populations; and federally listed, candidate, or State-listed endangered or threatened species in the treatment area. Preparation of site-specific EA's will include Federal and State land managers, the Fish and Wildlife Service, State wildlife officials, and the APHIS officer in charge. If significant unmitigated adverse effects are indicated, an EIS would be required before treatment could be considered.

In addition, this EIS will be supplemented as necessary to incorporate future analyses of control methods currently being tested as those methods become available for implementation in the APHIS cooperative control program. To the extent possible, the discussion of issues in this programmatic EIS may be incorporated by reference into any future analyses.

ENDANGERED AND THREATENED SPECIES AND CRITICAL HABITAT REQUIREMENTS

Federal policies and procedures for protecting endangered and threatened species of fish, wildlife, and plants were established by the Endangered Species Act of 1973 as amended (16 U.S.C. 1531 et seq.), and regulations were issued pursuant to the act. The objectives of the act are to provide mechanisms for conservation of endangered and threatened species and the habitats they depend on and to achieve the goals of international treaties and conventions related to endangered species. Under the act, the Secretary of the Interior is required to determine which species are endangered or threatened and to issue regulations to protect those species.

Section 7 of the act requires Federal agencies to consult with the U.S. Fish and Wildlife Service or the National Marine Fisheries Service to ensure that any action that they authorize, fund, or carry out is not likely to jeopardize the continued survival of a listed species or result in the adverse modification or destruction of its critical habitat (16 U.S.C. 1536(a)(2)). In addition, the act requires that if species proposed for listing are likely to be jeopardized, a conference must be held with the Fish and Wildlife Service.

Upon determination that an endangered or threatened species may be present in an area of a proposed action, the responsible agency must conduct a Biological Assessment to identify how the listed species might be affected. APHIS has prepared a biological assessment for all of the States involved in the cooperative grasshopper control program and is committed to preventing adverse impacts on listed species or their critical habitat. As part of the biological assessment process, APHIS has listed all federally endangered and threatened species for each county in which treatments might occur and proposed programmatic protection measures to prevent adverse effects to these species from treatments. These protection measures are presented in the Biological Assessment (available from APHIS) and may be modified in the Biological Opinion (available from the Fish and Wildlife Service). In addition, the field-level conferences with the Fish and Wildlife Service will be a component of all control activities to develop biological and distributional data for federally listed species.

As discussed previously, site-specific environmental assessments will also involve cooperation with the Fish and Wildlife Service and State wildlife specialists to evaluate impacts on species that are candidates for Federal listing, State-listed species, and unstable or limited range species. Appropriate protection measures for these species will be identified in site-specific environmental assessments.

FISH AND WILDLIFE CONSERVATION REQUIREMENTS

The Fish and Wildlife Conservation Act of 1980 (16 U.S.C. 2901 et seq.) encourages Federal agencies to conserve and promote conservation of nongame fish and wildlife and their habitats to the maximum extent possible within each agency's statutory responsibilities. It also assists States in developing fish and wildlife conservation plans.

The proposed grasshopper and Mormon cricket control program has been designed to minimize adverse impacts on fish and wildlife. Potential adverse impacts to fish would be minimized by observing appropriate stream buffer zones during pesticide applications and by following other operational procedures. In addition, measures to protect endangered and threatened wildlife have been adopted by APHIS as described in the section above.

The Migratory Bird Treaty Act, as amended (16 U.S.C. 703-711), prohibits the killing, capturing, or transporting of protected migratory birds, their nests, and eggs. Under this act, consultations with the Fish and Wildlife Service and State agencies are encouraged if project activities could directly or indirectly harm migratory birds. APHIS, in cooperation with the Fish and Wildlife Service, has developed a research project to study the impacts of control methods on migratory birds on the IPM demonstration sites. (See the description of the IPM pilot project in chapter 2.)

HERITAGE CONSERVATION REQUIREMENTS

A number of Federal laws and regulations have been promulgated to protect the Nation's historic, cultural, and prehistoric resources. These include the National Historic Preservation Act, the Archeological and Historic Preservation Act, the Archeological Resources Protection Act, the American Indian Religious Freedom Act, the National Natural Landmarks Program, and the World Heritage List. In addition, most States have established programs designed to protect cultural and archeological resources.

Compliance with Federal requirements concerning heritage conservation is largely accomplished at the programmatic level. APHIS' activities are not likely to have any effect upon National Register sites. The Advisory Council on Historic Preservation's prescriptions for protection of newly discovered properties will be followed (30 CFR 800.7).

WETLANDS PROTECTION REQUIREMENTS

Executive Order 11990 requires Federal agencies to minimize the loss or degradation of wetlands while carrying out their responsibilities. Many States, particularly coastal States, have also implemented programs designed to protect wetlands.

None of the APHIS grasshopper and Mormon cricket control activities on rangelands should directly affect any wetlands. However, the potential does exist for control activities to have indirect effects on wetlands. Potential adverse impacts would be avoided by the operational procedures described in this EIS (such as buffer zones) and by compliance with all applicable Federal environmental regulations.

RECREATION RESOURCES REQUIREMENTS

A number of Federal programs have been created to protect important national recreational resources. These include the National Wild and Scenic Rivers System, established by the Wild and Scenic Rivers Act (16 U.S.C. 1271 et seq.); the National Trails System, established by the National Trails System Act (16 U.S.C. 1241 et seq.); wilderness areas administered by the USDA Forest Service, Bureau of Land Management, National Park Service, and Fish and Wildlife Service; areas of critical environmental concern administered by BLM; and estuarine sanctuaries designated under the Coastal Zone Management Programs.

In general, these programs include provisions to discourage Federal agencies from taking actions that would impair the recognized values of the recreational resources in question. The Wild and Scenic Rivers Act restricts Federal agency participation in water projects that would affect designated wild or scenic rivers. Pursuant to the act, a nationwide inventory listed rivers potentially qualified for inclusion in the Wild and Scenic Rivers System. Federal agencies are required to consult with the Department of the Interior or the Department of Agriculture before taking actions that might foreclose wild, scenic, or recreational river status for the inventoried rivers (45 FR 59190, September 8, 1980). Primary emphasis in the administration of wild and scenic rivers is to be given to protecting aesthetic and scenic features as well as other values (Public Law 90-542, Sec. 10).

Similar regulations protect the scenic and recreational qualities of designated wilderness areas and wilderness study areas (44 FR 720114, December 12, 1979). Chemical treatments are discouraged in these areas except in cases when public health and safety or economic values are at severe risk from grasshopper infestations. Under this circumstance, a site-specific EIS for a designated wilderness area or a site-specific EA for a wilderness study area must be prepared. Each must include an evaluation of the impacts of the treatment on the naturalness, the outstanding opportunities for solitude, the outstanding opportunities for primitive and unconfined recreation, and the supplemental values of the wilderness area.

The National Trails System Act discourages activities by Federal agencies that limit access opportunities to designated trails or that are incompatible with recreational uses.

A BLM area of critical environmental concern (ACEC) is an area within public lands where special management attention is required to protect and prevent irreparable damage to important resources or to protect human life and safety from natural hazards (45 FR 57320, August 27, 1980). An ACEC designation may allow multiple-use activities, including development and commodity production, if they are compatible with the recognized resource values and if they are not detrimental to human property or lives. The management requirements for each ACEC are determined specifically to fit the resources or hazards at the particular site involved. Managers designate ACEC's and approve ACEC management plans.

There are also numerous State programs designed to enhance and protect recreational resources. Most States administer systems of State parks and State forests, and many also have programs that designate and protect scenic rivers in addition to those in the federally designated system. States may also administer

game or wildlife management areas, natural areas, scenic and recreational trails, or other environmentally sensitive areas.

Federal or State land managers will be involved in any cooperative control efforts on their lands. APHIS does not conduct chemical treatments on national parks, although Nosema may be used in these areas. Nosema is also available for use on other public lands, where chemicals may not be appropriate. Potential adverse impacts would be avoided on other lands by following each land management agency's regulations and policies regarding recreation resources; by following the programmatic operational procedures in table 2-1 designed to protect the public and natural resources, including water bodies; and through site-specific analysis.

AIR QUALITY REQUIREMENTS

The Clean Air Act Amendments of 1977 (42 U.S.C. 1857 et seq.) establish the basic framework for Federal, State, and local air quality management programs. National ambient air quality standards are promulgated as primary standards (for the protection of human health) and secondary standards (for the protection of other values such as crops and materials). The major implementation provision of the Clean Air Act requires each State to develop and implement a plan to achieve the Federal ambient air quality standards within specified time limits. The resulting State implementation plans (SIP's) provide the basic regulatory programs for controlling pollutant emissions from existing and future emission sources.

Areas that fail to meet a Federal primary air quality standard (nonattainment areas) are required to control both existing and new emission sources to achieve annual incremental reductions in pollutant emissions until the Federal standard is met.

EPA has not identified any of the pesticides under consideration in this EIS as hazardous air pollutants to be regulated under Section 112 of the Clean Air Act. Site-specific treatments will be designed to satisfy applicable Federal and State air quality laws and regulations, including State Implementation Plans.

WATER QUALITY REQUIREMENTS

The Clean Water Act (CWA), as amended (33 U.S.C. 1251 et seq.), sets forth the national strategy for controlling water pollution. The law prescribes national water quality goals and policies, establishes uniform effluent discharge limitations, requires States to establish and enforce water quality standards, establishes various levels of water quality planning, and establishes a National Pollutant Discharge Elimination System permit program for municipal and industrial point source discharges.

Section 208 of the CWA specifies State-level programs for controlling nonpoint source pollution. States are required to

prepare water quality management plans to achieve the act's goal of fishable and swimmable waters. In these plans, States must establish regulatory programs to control runoff and other pollution associated with agriculture, forestry, construction, and other nonpoint sources of pollution. Water quality management plans are prepared for specific watersheds and regions of each State and pertain to the conditions and activities present in those watersheds or regions.

Section 303 of the Clean Water Act specifies requirements for State water quality standards. Under section 303 and additional EPA regulations pertaining to water quality standards (40 CFR 120), States are required to establish and enforce water quality standards that protect public health and welfare and protect downstream water quality. Existing water quality standards are to be upgraded to achieve the CWA's goals of waters suitable for fishing and swimming.

Because grasshopper and Mormon cricket control activities do not involve point source discharges of pollutants, the provisions of the Clean Water Act pertaining to point source pollutant discharges would not apply. However, these activities would have the potential to cause nonpoint source discharges. Potential adverse impacts would be mitigated by using the operational procedures described in this EIS and by complying with all applicable local, State, and Federal regulations and standards concerning water quality as required by section 313(a) of the Clean Water Act.

GROUND-WATER QUALITY REQUIREMENTS

The Safe Drinking Water Act (SDWA)(42 U.S.C. 300f et seq.) allows EPA to designate any aquifer that serves as the principal source of drinking water for an area as a "sole source" aquifer. Federal agencies are prevented from granting assistance to any project that may contaminate such an aquifer so as to create a significant health hazard (Section 1424, SDWA). To date, some 20 sole source aquifers have been designated, and approximately 15 others have been proposed for consideration. EPA's Office of Drinking Water maintains information on the location of these aquifers. An analysis of the probability that the recharge zone of any aquifer, sole source or other, would be contaminated by chemicals used in grasshopper and Mormon cricket control activities is described in chapter 4, along with potential impacts to drinking water.

NOISE CONTROL REQUIREMENTS

The Noise Control Act of 1972 (42 U.S.C. 4901 et seq.) establishes a Federal policy, as well as various programs, for the control of noise that is detrimental to public health and welfare. Section 4(b) of the act requires each Federal agency engaged in noise-emitting activities to comply with Federal, State, and local requirements for control and abatement of environmental noise. Typically, permanent noise sources are regulated more strictly at all levels than temporary noise

sources, and industrial sources are regulated more strictly than silvicultural or agricultural activities.

Any noise from APHIS cooperative control operations would be temporary and would not have greater impacts than current agricultural spraying operations in the area. Aerial treatments would be avoided in sensitive areas containing endangered and threatened species and around schools, parks, congested areas, or other sensitive receptors. Plans to fly over congested areas must be submitted to the Federal Aviation Administration's district office having jurisdiction over that area. Although these guidelines are primarily safety-motivated, they would serve to limit noise impacts in local towns.

PESTICIDE REGULATION

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended (7 U.S.C. 136 et seq.), establishes procedures for the registration, classification, and regulation of all pesticides. EPA is responsible for implementing FIFRA. Primary enforcement responsibility under FIFRA for use-related violations is assigned to States with approved programs. Before any pesticide may be sold legally, it must be registered by EPA. EPA may classify a pesticide for restricted use if it determines that without restrictions on use, the pesticide may cause unreasonable adverse effects on applicators or the environment. Restricted-use pesticides may be applied only by or under the direct supervision of a certified applicator or in accordance with other restrictions (Section 3(d), FIFRA). States also may classify pesticides; in some cases, States have classified individual pesticides for restricted use, although EPA has not done so. None of the pesticides considered for use in this EIS are classified as restricted by EPA. Regulations for the storage and disposal of pesticide containers and excess amounts of pesticides have also been promulgated by EPA and by the States.

The operational procedures described in this EIS are designed to satisfy applicable FIFRA requirements. Only pesticides registered by EPA will be used in grasshopper control activities in strict accordance with EPA-approved and applicable State-approved label instructions. Some of the specific operational procedures listed in table 2-1 are derived from label requirements applicable to all three insecticides considered for use. However, APHIS and its cooperators would be required to comply with all label requirements that may be unique to each insecticide.

Section 408 of the Federal Food, Drug, and Cosmetic Act (FFDCA) authorizes the establishment of tolerance levels of pesticides on food or feed crops. These tolerance levels, set by EPA, are the amounts of pesticide residues that may safely remain on food or feed crops after harvest. The Food and Drug

Administration and the Department of Agriculture enforce tolerance levels by inspecting agricultural commodities, meat, and poultry before sale.

As discussed in chapter 4, small amounts of infested croplands usually exist within a proposed rangeland treatment area. The pesticides under consideration for APHIS' long-range program are broadly registered for most crops likely to be included in a treatment area. However, if the treatment area contains a crop for which the pesticide is not registered, APHIS will not spray chemicals within 500 feet of the cropland. Restrictions for the use of carbaryl bait in the vicinity of crops are identified in table 2-1.

Chapter 6
List of Preparers

Table 6-1 lists the people involved in the preparation of this environmental impact statement, together with their education and responsibility in preparing this EIS. LABAT-ANDERSON Incorporated managed the preparation of the EIS under the direction of APHIS and the cooperating agencies. Table 6-2 lists representatives of each of the cooperating agencies and EPA that were involved in the preparation and review of this EIS.

Table 6-1--List of preparers

Name	Affiliation	Education	EIS responsibility
		USDA--APHIS	
Michael Shannon	USDA APHIS PPQ	B.S., Biology	Technical Information and Policy Support
Charles H. Bare	USDA APHIS PPQ	B.S., Agriculture	Contracting Officer's Representative, Technical Information Support
		Contractor--Labat-Anderson Incorporated	
Andrea Myslicki	Labat-Anderson Incorporated	B.S., Environmental Science M.P.A., Public Administration	Project Manager
Anne Vor der Bruegge	Labat-Anderson Incorporated	B.A., Environmental Psychology/Anthropology M.P., Urban and Environmental Planning	Acting Project Manager, NEPA Compliance
Dr. Philip Sczerzenie	Labat-Anderson Incorporated	B.S., Forestry and Wildlife Ecology M.S., Wildlife Biology Ph.D., Wildlife Biology	Technical Team Leader
Dr. Richard Thomas	Thomas and Thomas, Inc.	B.S., Chemistry Ph.D., Medicinal Chemistry	Review of Hazard Analysis
John Weeks	Labat-Anderson Incorporated	B.S., Biology and Physical Sciences M.S., Biostatistics, Population Biology M.F., Forest Resource Management	Transport and Fate Modeling, Human Health Risk Assessment
Gary Drendel	Labat-Anderson Incorporated	B.S., Zoology M.S., Zoology and Environmental Studies	Wildlife and Aquatic Hazard Analysis, Aquatic Risk Analysis, Vegetation Impacts, Environmental Fate Analysis
Stuart Strum	Labat-Anderson Incorporated	B.S., Geology M.S., Geology Postgraduate Studies, Geochemistry	Environmental Fate Analysis
Jack T. Mozingo, Jr.	Labat-Anderson Incorporated	B.S., Environmental Studies and Psychology M.S., Environmental Science	Description of Control Methods, Operational Procedures
Carol Crouch	Labat-Anderson Incorporated	B.S., Microbiology	Human Health Risk Assessment
Donna Hill	Labat-Anderson Incorporated	B.A., Liberal Arts	Description of the Affected Environment
Tedi McManus	Labat-Anderson Incorporated	B.S., Wildlife Resources M.A., Wildlife Ecology	Wildlife and Vegetation Impacts Research
Renita S. Jagan	Labat-Anderson Incorporated	B.A., Biology and Psychology	Research on the Affected Environment, Soils
Marie Kerr	Labat-Anderson Incorporated	B.A., English M.A., English	Senior Technical Editor
Doris Edelin	Labat-Anderson Incorporated	Wang Laboratories, 1980	Lead word processing operator

Table 6-2--Cooperating agency contacts

Name	Agency
Richard Fowler	U.S. Department of Agriculture, Forest Service Forest Pest Management
Gerald Henke	U.S. Department of Agriculture, Forest Service Range Management
Sarah Gerould	U.S. Department of the Interior, Fish and Wildlife Service
Lewis Waters	U.S. Department of the Interior, Bureau of Land Management Division of Forestry and Pest Management
William Harkenrider	U.S. Department of the Interior, Bureau of Land Management Division of Rangeland Resources
Paul Kaldjian	U.S. Environmental Protection Agency, Office of Federal Activities

Chapter 7
Distribution List

FEDERAL AGENCIES

U.S. Department of Agriculture

USDA Government and Public Affairs
Office of Intergovernmental Affairs
Room 102-A, Administration Building
Washington, DC 20250

Office of Budget, Planning, and
Evaluation
U.S. Department of Agriculture
Room 143-E, Administration Building
13th and Independence Avenue
Washington, DC 20250

Dr. Kenneth H. Knauer
Acting Director, Forest Pest
Management
USDA Forest Service
P.O. Box 2417
Washington, DC 20013

Administrator
Agricultural Research Service
U.S. Department of Agriculture
Room 302-A
Washington, DC 20250

Administrator
Extension Service
U.S. Department of Agriculture
Room 5039-S
Washington, DC 20250

Mr. Dale Robertson
Chief, Forest Service
U.S. Department of Agriculture
Room 3008-S
P.O. Box 2417
Washington, DC 20013

Mr. Roger Sandman
Deputy Director for
Intergovernmental Affairs
U.S. Department of Agriculture
Washington, DC 20250

Mr. Jerome A. Onsager
USDA Agriculture Research Service-WR
Montana State University
Rangeland Insect Laboratory
South 11th Avenue
Bozeman, MT 59717

Mr. Dennis R. Hamel
Forest Pest Management
USDA Forest Service
P.O. Box 2417
Washington, DC 20013

Mr. Max M. Ollieu
Forest Pest Management
USDA Forest Service
P.O. Box 2417
Washington, DC 20013

Mr. Dave Ketcham
Office of Environmental
Coordination
USDA Forest Service
Room 4204-SB
Washington, DC 20250

Mr. Garth Baxter
State and Private Forestry
USDA Forest Service, Region 4
Federal Building
324 25th Street
Ogden, UT 84401

Mr. Robert S. Carpenter
USDA Forest Service
5493 Warm Springs Avenue
Boise, ID 83712

Mr. David A. Filius
USDA Forest Service
2602 First Avenue North
P.O. Box 2556
Billings, MT 59103

Dr. Robert D. Averill
Group Leader Entomology
USDA Forest Service
TFP and CPM, R-2
P.O. Box 25127
Lakewood, CO 80225

Dr. Richard F. Fowler
Forest Pest Management
USDA Forest Service
P.O. Box 2417
Washington, DC 20013

Mr. Gerald Henke
Range Management
USDA Forest Service
P.O. Box 2417
Washington, DC 20013

Mr. Mark Petroni
USDA Forest Service
Ashland District
Ashland, MT 59003

Mr. Jim Fishburn
Custer National Forest
USDA Forest Service
2602 1st Avenue North
Billings, MT 59101

Brent Handley
Range Assistant
USDA Forest Service
Route 6, Box 131B
Dickinson, ND 58601

Cary Frost
Range Resource Assistant
USDA Forest Service
Star Route 2, Box 8
Watford City, ND 58854

Animal and Plant Health
Inspection Service
Plant Protection Quarantine
U.S. Department of Agriculture
Room 566, Federal Building
200 NW Fifth Street
Oklahoma City, OK 73102

U.S. Department of Defense

Dr. Terry Biery
Department of the Air Force
355 TAS/Aerial Spray
Rickenbacker ANGB, OH 43217

Mr. Eric N. Anderson
Range Conservationist
Department of the Army
Headquarters, Yakima Firing Center
Directorate of Engineering and Housing
Yakima, WA 98901

Commander
HQ., I Corps and Fort Lewis
Fort Lewis, WA 98433-5000
ATTN: AFZH-EHQ (Mr. Stedman)

U.S. Department of Energy

Mr. Nelson Thomas
Richland Operations Office
Site & Laboratory Management Division
Department of Energy
P.O. Box 550
Richland, WA 99352

U.S. Department of Health and Human Services

Mr. M. Zeeman
Food and Drug Administration
CVM, HFV-152
5600 Fishers Lane
Rockville, MD 20857

U.S. Department of the Interior

Mr. Robert Pizel
Division of Planning and
Environmental Coordinator
Bureau of Land Management
U.S. Department of the Interior
1725 I Street NW, Room 906
Washington, DC 20006

Chief, Division of Environmental
Contaminants
Fish and Wildlife Service
U.S. Department of the Interior
Room 401, Hamilton Building
18th and C Streets, NW
Washington, DC 20240

Ms. Sarah Gerould
Division of Environmental Contaminants
Fish and Wildlife Service/
Fish and Wildlife Enhancement
U.S. Department of the Interior
Room 401, Hamilton Building
18th and C Streets, NW
Washington, DC 20240

Chief, Ofice of Endangered Species
Fish and Wildlife Service
U.S. Department of the Interior
5th Floor, Broyhill Building
Washington, DC 20240

Mr. Buck Waters
Division of Forestry (230)
Bureau of Land Management
U.S. Department of the Interior
901 Premier Building
18th and C Streets, NW
Washington, DC 20240

Mr. Bruce Blanchard
Director
Office of Environmental
Project Review
Office of the Secretary
U.S. Department of the Interior
Washington, DC 20240

Mr. Tom Loomis
Office of Environmental Project Review
U.S. Department of the Interior
Room 4244
Washington, DC 20240

Mr. Gary Cummins
Office of Environmental Project
Review
U.S. Department of the Interior
Room 4229, Main Interior Building
18th and C Streets, NW
Washington, DC 20240

Mr. David G. Wright
Associate Director, Planning and
Development
U.S. Department of the Interior
P.O. Box 37127
Washington, DC 20013-7127

Ms. Suzanne Mayer
Acting Associate Director
Fish and Wildlife Service
U.S. Department of the Interior
Washington, DC 20240

Ms. Mildred Glouster
Bureau of Mines
U.S. Department of the Interior
2401 E Street, NW
Room 819
Washington, DC 20241

Mr. Dale Morlock
National Park Service (762)
P.O. Box 37127
Washington, DC 20013-7197

Mr. Gary Johnston
Biological Support Staff
National Park Service
U.S. Department of the Interior
Washington, DC 20013

Mr. Larry Kline
Fish and Wildlife Service
U.S. Department of the Interior
5th Floor
1000 North Glebe Road
Arlington, VA 22201

Mr. Clark Johnson
Fish and Wildlife Service
U.S. Department of the Interior
2060 Administration Building
1745 West 1700 South
Salt Lake City, UT 84104-5110

Endangered Species Field Station
Fish and Wildlife Service
U.S. Department of the Interior
1745 W. 1700 South, Room 2078
Salt Lake City, UT 84104-5110

Field Supervisor
Fish and Wildlife Service
U.S. Department of the Interior
2060 Administration Building
1745 West 1700 South
Salt Lake City, UT 84104-5110

Mr. Robert L. McCue
Fish and Wildlife Service
U.S. Department of the Interior
2060 Administration Building
1745 West 1700 Street
Salt Lake City, UT 84104

Mr. Wayne Brewster
Field Supervisor
Fish and Wildlife Service
U.S. Department of the Interior
P.O. Box 10023
Helena, MT 59626

Endangered Species Field Station
Fish and Wildlife Service
U.S. Department of the Interior
P.O. Box 10023
Helena, MT 59626

Field Supervisor
Fish and Wildlife Service
U.S. Department of the Interior
Federal Bldg., Room 3035
316 North 26th Street
Billings, MT 59101

Regional Director
Fish and Wildlife Service
U.S. Department of the Interior
Denver Federal Center
P.O. Box 25486
Denver, CO 80225

Assistant Regional Director
Fish and Wildlife Service
U.S. Department of the Interior
P.O. Box 25486
Denver Federal Center
Denver, CO 80225

Field Supervisor
Fish and Wildlife Service
U.S. Department of the Interior
529 - 25 1/2 Road, Suite B-113
Independence Plaza
Grand Junction, CO 81501

Endangered Species Field Station
Fish and Wildlife Service
U.S. Department of the Interior
4696 Overland Road, Room 238
Boise, ID 83705

Field Supervisor
Fish and Wildlife Service
U.S. Department of the Interior
4696 Overland Road, Room 576
Boise, ID 83705

Endangered Species Field Station
Fish and Wildlife Service
U.S. Department of the Interior
Building A, 2695 Parkmont Lane
Olympia, WA 98502

Field Supervisor
Fish and Wildlife Service
U.S. Department of the Interior
2625 Parkmont Lane SW, Bldg. B3
Olympia, WA 98502

Endangered Species Field Station
Fish and Wildlife Service
U.S. Department of the Interior
4600 Kietzke Lane
Building C
Reno, NV 89502

Field Supervisor
Fish and Wildlife Service
U.S. Department of the Interior
4600 Kietzke Lane, Suite C
Reno, NV 89502

Field Supervisor
Fish and Wildlife Service
U.S. Department of the Interior
2800 Cottage Way, Room E-2727
Sacramento, CA 95825

Endangered Species Field Station
Fish and Wildlife Service
U.S. Department of the Interior
2800 Cottage Way, Room E-1823
Sacramento, CA 95825

Field Supervisor
Fish and Wildlife Service
U.S. Department of the Interior
Federal Bldg., 24000 Avila Rd.
Laguna Niguel, CA 92677

Assistant Regional Director
U.S. Department of the Interior
Fish and Wildlife Service
P.O. Box 1306
Albuquerque, NM 87103

Field Supervisor
Fish and Wildlife Service
U.S. Department of the Interior
P.O. Box 4487
Albuquerque, NM 87196

Field Supervisor
Fish and Wildlife Service
U.S. Department of the Interior
2934 West Fairmount Avenue
Phoenix, AZ 85017

Field Supervisor
Fish and Wildlife Service
U.S. Department of the Interior
222 South Houston, Suite A
Tulsa, OK 74127

Field Supervisor
Fish and Wildlife Service
U.S. Department of the Interior
9A33 Fritz Lanham Building
819 Taylor Street
Forth Worth, TX 76102

Field Supervisor
Fish and Wildlife Service
Corpus Christi State University
Campus Box 338, 6300 Ocean Dr.
Corpus Christi, TX 78412

Field Supervisor
Fish and Wildlife Service
U.S. Department of the Interior
17629 El Camino Real, Suite 211
Houston, TX 77058

Assistant Regional Director
Fish and Wildlife Service
U.S. Department of the Interior
Lloyd 500 Building, Suite 1692
500 NE Multnomah Street
Portland, OR 97232

Field Supervisor
Fish and Wildlife Service
U.S. Department of the Interior
727 NE 24th Avenue
Portland, OR 97232

Field Supervisor
Fish and Wildlife Service
U.S. Department of the Interior
2604 St. Patrick, Suite 7
Grand Island, NE 68801

M. S. Zschomler
Field Supervisor, Habitat Resources
Fish and Wildlife Service
U.S. Department of the Interior
1500 Capitol Avenue
Bismarck, ND 58501

Field Supervisor
Fish and Wildlife Service
U.S. Department of the Interior
227 Federal Building
P.O. Box 986
Pierre, SD 57501

Mr. Kent Keenlyne
Fish and Wildlife Service
U.S. Department of the Interior
227 Federal Building
Pierre, SD 57501

Mr. David Goeke
Refuge Manager
Columbia National Wildlife Refuge
Fish and Wildlife Service
U.S. Department of the Interior
P.O. Drawer F
Othello, WA 99344

Ms. Ellen Snyder Sonn
Fish and Wildlife Service
U.S. Department of the Interior
101 12th Avenue
Box 20 Federal Building
Fairbanks, AK 99701

Jimmie L. Pribble
Colorado State Office
Bureau of Land Management
U.S. Department of the Interior
2020 Arapahoe Street
Denver, CO 80205

Dale Brubaker
Bureau of Land Management
U.S. Department of the Interior
2020 Arapahoe Street
Denver, CO 80205

Ms. Margot Zallen
Office of the Solicitor
U.S. Department of the Interior
P.O. Box 25007
Denver Federal Center
Denver, CO 80225

State Director (930)
Bureau of Land Management
U.S. Department of the Interior
P.O. Box 1828
Cheyenne, WY 82003

Mr. Frank Maxwell
Las Vegas District Office
Bureau of Land Management
U.S. Department of the Interior
P.O. Box 26569
Las Vegas, NV 89126

Mr. Robert Tigner
Bureau of Land Management
U.S. Department of the Interior
P.O. Box 670
Rawlins, WY 82301

Mr. Gregg Dawson
Bureau of Land Management
U.S. Department of the Interior
P.O. Box M
Moab, UT 84532

Mr. Jerry Fullerton
Bureau of Land Management
U.S. Department of the Interior
P.O. Box 2965
Portland, OR 97208

Mr. H. Robert Moore
Colorado State Office
Bureau of Land Management
U.S. Department of the Interior
2020 Arapahoe Street
Denver, CO 80205

Mr. John A. Kwiatkowski
Bureau of Land Management
U.S. Department of the Interior
P.O. Box 36800
Billings, MT 59107

Mr. Harlan Hayes
Bureau of Land Management
U.S. Department of the Interior
P.O. Box 36800
Billings, MT 59107

Mr. Delmar D. Vail
State Director
Idaho State Office
Bureau of Land Management
U.S. Department of the Interior
3380 Americana Terrace
Boise, ID 83706

Mr. Steve Ellis
Bureau of Land Management
U.S. Department of the Interior
3380 Americana Terrace
Boise, ID 83707

Ms. Lynn Williams
Bureau of Land Management
324 So. State, Suite 301
Salt Lake City, UT 84111-2303

Mr. Stan Clemens
Bureau of Indian Affairs
U.S. Department of the Interior
316 North 26th Street
Billings, MT 59101

Mr. Dennis Olson
Land Operations Officer
Bureau of Indian Affairs
U.S. Department of the Interior
Spokane Indian Reservation
Wellpinit, WA 99040

Mr. James Orwin
Natural Resource Officer
Bureau of Indian Affairs
U.S. Department of the Interior
Colville Indian Agency
Nespelem, WA 99155

Mr. Bill Ericksen
Range Conservationist
Bureau of Indian Affairs
U.S. Department of the Interior
Yakima Indian Agency
P.O. Box 1632
Toppenish, WA 98948

Mr. Joseph Buesing
District Manager
Bureau of Land Management
U.S. Department of the Interior
4217 E. Main
Spokane, WA 99202

Mr. James Fisher
District Director
Bureau of Land Management
U.S. Department of the Interior
1133 North Western
Wenatchee, WA 98801

Mr. Bill Gray
Chief
Land Resources Branch
Bureau of Reclamation
U.S. Department of the Interior
P.O. Box 815
Ephrata, WA 98823

U.S. Department of State

R. H. Davidson, P.Ag.
First Secretary
Canadian Embassy
1746 Massachusetts Avenue, NW
Washington, DC 20036

U.S. Environmental Protection Agency

Mr. Richard E. Sanderson
Director
Office of Federal Activities
U.S. Environmental Protection Agency
401 M Street, NW
Washington, DC 20460

Mr. Paul Kaldjian
Office of Federal Activities
U.S. Environmental Protection Agency
401 M Street, SW
Washington, DC 20460

Ms. Margaret Schneider
Office of Federal Activities
U.S. Environmental Protection Agency
Room A104
401 M Street, SW
Washington, DC 20460

U.S. House of Representatives

Honorable Beau Boulter
House of Representatives
Rm. 124 Canon House Office Building
Washington, DC 20515

Honorable George E. Brown, Jr.
Chairman, Department Operations, Research, and Foreign Agriculture
Committee on Agriculture
House of Representatives
Washington, DC 20515

Honorable Hank Brown
House of Representatives
Rm. 1424 Longworth House Office Building
Washington, DC 20515

Honorable Ben Nighthouse Campbell
House of Representatives
Rm. 1724 Longworth House Office
Building
Washington, DC 20515

Honorable Richard B. Cheney
House of Representatives
Rm. 104 Canon House Office
Building
Washington, DC 20515

Honorable Ronald D. Coleman
House of Representatives
Rm. 416 Canon House Office
Building
Washington, DC 20515

Honorable Larry Combest
House of Representatives
Rm. 1529 Longworth House Office
Building
Washington, DC 20515

Honorable Larry E. Craig
House of Representatives
Rm. 1034 Longworth House Office
Building
Washington, DC 20515

Honorable Byron Dorgan
House of Representatives
Rm. 238 Canon House Office
Building
Washington, DC 20515

Honorable Glenn English
House of Representatives
Rm. 2235 Rayburn House Office
Building
Washington, DC 20515

Honorable Thomas S. Foley
House of Representatives
Rm. 1201 Longworth House Office
Building
Washington, DC 20515

Honorable Dan Glickman
House of Representatives
Rm. 1212 Longworth House Office
Building
Washington, DC 20515

Honorable James V. Hansen
House of Representatives
Rm. 1113 Longworth House Office
Building
Washington, DC 20515

Honorable Joel Hefley
House of Representatives
Rm. 508 Canon House Office
Building
Washington, DC 20515

Honorable James M. Inhofe
House of Representatives
Rm. 1017 Longworth House Office
Building
Washington, DC 20515

Honorable Tim Johnson
House of Representatives
Rm. 513 Canon House Office
Building
Washington, DC 20515

Honorable Jim Kolbe
House of Representatives
Rm. 1222 Longworth House Office
Building
Washington, DC 20515

Honorable Jon Kyl
House of Representatives
Rm. 313 Canon House Office
Building
Washington, DC 20515

Honorable Manuel Lujan, Jr.
House of Representatives
Rm. 1323 Longworth House Office
Building
Washington, DC 20515

Honorable Ron Marlenee
House of Representatives
Rm. 2465 Rayburn House Office
Building
Washington, DC 20515

Honorable Dave McCurdy
House of Representatives
Rm. 409 Canon House Office
Building
Washington, DC 20515

Honorable Jan Meyers
House of Representatives
Rm. 315 Canon House Office
  Building
Washington, DC 20515

Honorable Sid Morrison
House of Representatives
Rm. 1434 Longworth House Office
  Building
Washington, DC 20515

Honorable Howard C. Nielson
House of Representatives
Rm. 1229 Longworth House Office
  Building
Washington, DC 20515

Honorable William B. Richardson
House of Representatives
Rm. 332 Canon House Office
  Building
Washington, DC 20515

Honorable Pat Roberts
House of Representatives
Rm. 1314 Longworth House Office
  Building
Washington, DC 20515

Honorable Norman D. Shumway
House of Representatives
Rm. 1203 Longworth House Office
  Building
Washington, DC 20515

Honorable David Skaggs
House of Representatives
Rm. 1723 Longworth House Office
  Building
Washington, DC 20515

Honorable Joe Skeen
House of Representatives
Rm. 1007 Longworth House Office
  Building
Washington, DC 20515

Honorable James C. Slattery
House of Representatives
Rm. 1440 Longworth House Office
  Building
Washington, DC 20515

Honorable Robert F. Smith
House of Representatives
Rm. 118 Canon House Office
  Building
Washington, DC 20515

Honorable Virginia Smith
House of Representatives
Rm. 2202 Rayburn House Office
  Building
Washington, DC 20515

Honorable Richard H. Stallings
House of Representatives
Rm. 1221 Longworth House Office
  Building
Washington, DC 20515

Honorable Charles W. Stenholm
House of Representatives
Rm. 1226 Longworth House Office
  Building
Washington, DC 20515

Honorable Bob Stump
House of Representatives
Rm. 211 Canon House Office
  Building
Washington, DC 20515

Honorable Mike Synar
House of Representatives
Rm. 2441 Rayburn House Office
  Building
Washington, DC 20515

Honorable Morris K. Udall
House of Representatives
Rm. 235 Canon House Office
  Building
Washington, DC 20515

Honorable Barbara Vucanovich
House of Representatives
Rm. 312 Canon House Office
  Building
Washington, DC 20515

Honorable Wes Watkins
House of Representatives
Rm. 2348 Rayburn House Office
  Building
Washington, DC 20515

Honorable Bob Whittaker
House of Representatives
Rm. 2436 Rayburn House Office
  Building
Washington, DC 20515

Honorable Pat Williams
House of Representatives
Rm. 2457 Rayburn House Office
  Building
Washington, DC 20515

Honorable Don Young
House of Representatives
Rm. 2331 Rayburn House Office
  Building
Washington, DC 20515

<u>U.S. Senators</u>

Honorable Brock Adams
United States Senate
Rm. 513 Senate Hart
Washington, DC 20510

Honorable William L. Armstrong
United States Senate
Rm. 528 Senate Hart
Washington, DC 20510

Honorable Max Baucus
United States Senate
Rm. 706 Senate Hart
Washington, DC 20510

Honorable Lloyd Bentsen
United States Senate
Rm. 703 Senate Hart
Washington, DC 20510

Honorable Jeff Bingaman
United States Senate
Rm. 502 Senate Hart
Washington, DC 20510

Honorable David L. Boren
United States Senate
Rm. 453 Senate Russell
Washington, DC 20510

Honorable Quentin Burdick
United States Senate
Rm. 511 Senate Hart
Washington, DC 20510

Honorable Kent Conrad
United States Senate
Rm. 825A Senate Hart
Washington, DC 20510

Honorable Alan Cranston
United States Senate
Rm. 112 Senate Hart
Washington, DC 20510

Honorable Thomas A. Daschle
United States Senate
Rm. 724 Senate Hart
Washington, DC 20510

Honorable Dennis DeConcini
United States Senate
Rm. 328 Senate Hart
Washington, DC 20510

Honorable Robert Dole
United States Senate
Rm. 141 Senate Hart
Washington, DC 20510

Honorable Pete V. Domenici
United States Senate
Rm. 434 Senate Dirksen
Washington, DC 20510

Honorable Daniel J. Evans
United States Senate
Rm. 702 Senate Hart
Washington, DC 20510

Honorable J. James Exon
United States Senate
Rm. 330 Senate Hart
Washington, DC 20510

Honorable Jake Garn
United States Senate
Rm. 505 Senate Dirksen
Washington, DC 20510

Honorable Phil Gramm
United States Senate
Rm. 370 Senate Russell
Washington, DC 20510

Honorable Orrin G. Hatch
United States Senate
Rm. 135 Senate Russell
Washington, DC 20510

Honorable Mark O. Hatfield
United States Senate
Rm. 711 Senate Hart
Washington, DC 20510

Honorable Chic Hecht
United States Senate
Rm. 302 Senate Hart
Washington, DC 20510

Mr. Lee Jacobson
Office of Senator Jim McClure
Room 149
Borah Station
Boise, ID 83703

Honorable Nancy L. Kassebaum
United States Senate
Rm. 302 Senate Russell
Washington, DC 20510

Honorable Jim McCain
United States Senate
Rm. 363 Senate Russell
Washington, DC 20510

Honorable John Melcher
Chairman, Subcommittee on Agricultural
Research, Conservation, Forestry,
and General Legislation
Committee on Agriculture, Nutrition,
and Forestry
United States Senate
Washington, DC 20510

Honorable James A. McClure
United States Senate
Rm. 361 Senate Dirksen
Washington, DC 20510

Honorable Frank H. Murkowski
United States Senate
Rm. 709 Senate Hart
Washington, DC 20510

Honorable Don Nickles
United States Senate
Rm. 713 Senate Hart
Washington, DC 20510

Honorable Bob Packwood
United States Senate
Rm. 259 Senate Russell
Washington, DC 20510

Honorable Larry Pressler
United States Senate
Rm. 407A Senate Russell
Washington, DC 20510

Honorable Harry Reid
United States Senate
Rm. 708 Senate Hart
Washington, DC 20510

Honorable Alan K. Simpson
United States Senate
Rm. 261 Senate Dirksen
Washington, DC 20510

Kevin Spencer, Staff Assistant
Office of Senator Steve Symms
P.O. Box 1190
Boise, ID 83702

Honorable Ted Stevens
United States Senate
Rm. 522 Senate Hart
Washington, DC 20510

Honorable Steven D. Symms
United States Senate
Rm. 509 Senate Hart
Washington, DC 20510

Honorable Malcolm Wallop
United States Senate
Rm. 206 Senate Russell
Washington, DC 20510

Honorable Pete Wilson
United States Senate
Rm. 720 Senate Hart
Washington, DC 20510

Honorable Timothy W. Wirth
United States Senate
Rm. 237 Senate Russell
Washington, DC 20510

Honorable Ed Zorinsky
United States Senate
Rm. 443 Senate Russell
Washington, DC 20510

State Attorney General

Mr. Steve Addington
Office of the Attorney General
Attorney General Statehouse
Boise, ID 83702

State Legislature

Ms. Frances Field
State Legislature Representative
HC-85, Box 221
Grand View, ID 83624

STATE AND LOCAL AGENCIES

Alaska

Mr. Bill L. Heim, Director
Department of Natural Resources
State of Alaska
P.O. Box 949
Palmer, AK 99645-0949

Arizona

Plant Quarantine Division
Arizona Commission of Agriculture
and Horticulture
1688 West Adams
Phoenix, AZ 85007

Mr. Duane L. Shroufe
Acting Director
Arizona Game and Fish Department
2222 West Greenway Road
Phoenix, AZ 85023

Director and State Entomologist
Arizona Commission of Agriculture
and Horticulture
1688 West Adams, #421
Phoenix, AZ 85007

California

Mr. Dick Thompson
Information Officer
California Department of Food
and Agriculture
1220 N Street
Sacramento, CA 95814

Chief of Pest Exclusion
California Department of Food
and Agriculture
1220 N Street
Sacramento, CA 95814

Mr. Ed Hale
Agricultural Commissioner
Inyo/Mono Counties
Director of Weight and Measures
207 W. South Street
Bishop, CA 93514

Curator
Plant Industry Reference Room
California Department of Food
and Agriculture
1220 N Street, Room 312
Sacramento, CA 95814

Mr. Charles D. Hunter
Environmental Monitoring and Pest
Management
California Department of Food
and Agriculture
3288 Meadowview Road
Sacramento, CA 95831

Health and Safety Unit
Conservation Education Service
Department of Education
721 Capitol Mall
Sacramento, CA 95814

Colorado

Public Information Officer
Colorado Department of Agriculture
1525 Sherman Street, 4th floor
Denver, CO 80203

Mr. R. I. Sullivan, Director
Division of Plant Industry
Colorado Department of Agriculture
1525 Sherman Street
Denver, CO 80203

Mr. Thomas E. Lefevre
Chairman
Moffat County Board of
County Commissioners
221 West Victory Way
Craig, CO 81625

Mr. Allen Whitaker
Wildlife Program Specialist
Division of Wildlife
Colorado Department of Natural
Resources
6060 Broadway
Denver, CO 80216

Kansas

Information Officer
Kansas State Board of Agriculture
109 SW 9th Street
Topeka, KS 66612

State Entomologist-Plant Protection
Secretary
Kansas State Board of Agriculture
149 SW 9th Street
Topeka, KS 66612

Forestry, Fish, and Game
Commission
Box 1028
Pratt, KS 67124

Idaho

Information Director
Idaho Department of Agriculture
P.O. Box 790
Boise, ID 83701

Mr. David Proctor
Idaho Statesman
P.O. Box 40
Boise, ID 83707

Mr. Don Hobbs
Idaho Department of Lands
Statehouse
Boise, ID 83720

Administrator, Division of Plant
Industries
Idaho Department of Agriculture
P.O. Box 167
Boise, ID 83701

Montana

Director
Montana Department of Agriculture
Agriculture/Livestock Building
Capitol Station
Helena, MT 59620-0201

Administrator, Plant Industries
Division
Montana Department of Agriculture
Agriculture/Livestock Building
Capitol Station
Helena, MT 59620

Director
Department of Fish and Game
Helena, MT 59601

Mr. Bob Gillespie, Entomologist
State of Montana Department
of Agriculture
Environmental Management Division
Agriculture/Livestock Building
Capitol Station
Helena, MT 59620-0205

Mr. Keith Kelly
Montana Department of Agriculture
Agricultural Livestock Building
Capitol Station
6th & Roberts
Helena, MT 59620

Mr. Will Kissinger
Montana Department of Agriculture
Agricultural Livestock Building
Capitol Station
6th and Roberts
Helena, MT 59620

Mr. George Algaard
Montana Department of Agriculture
Agricultural Livestock Building
Capitol Station
6th and Roberts
Helena, MT 59620

Mr. Kirk Barnette
Big Horn County Extension Service
Courthouse, Room 101
Hardin, MT 59034

Nebraska

State Entomologist, Bureau of Plant Industries
Nebraska Department of Agriculture
P.O. Box 94756
Lincoln, NE 68509

Director
Game and Parks Commission
2200 N 33rd Street
P.O. Box 30370
Lincoln, NE 68503

Dr. Steve Knight
Survey Coordinator
Bureau of Plant Industry
Nebraska Department of Agriculture
P.O. Box 94756
Lincoln, NE 68509

Mr. John B. Campbell
Extension Entomology Specialist
Nebraska Cooperative Extension Service
West Central Research and Extension Center
Route 4, Box 46A
North Platte, NE 69101

Mr. Art Hagen
Extension Entomologist
Panhandle Extension and Research Center
4502 Avenue I
Scottsbluff, NE 69361

Mr. Gregg Rake
Nebraska Department of Agriculture
P.O. Box 46
Yucca Heights
Keyston, NE 69144

Nevada

Director
Division of Plant Industry
Nevada State Department of Agriculture
P.O. Box 11100
Reno, NV 89510

Director
Nevada Department of Wildlife
1100 Valley Road
P.O. Box 1067B
Reno, NV 89520-0022

New Mexico

Information Officer
New Mexico Department of Agriculture
P.O. Box 3189
Las Cruces, NM 88003

Mr. Harold F. Olson
Director
New Mexico Department of Fish and Game
State Capitol
Santa Fe, NM 87503

Chief, Bureau of Entomology and
Nursery Inc.
New Mexico Department of Agriculture
P.O. Box 3 BA
Las Cruces, NM 88003

Ms. Sharon Murray
New Mexico Environmental
Improvement Division
P.O. Box 968
Santa Fe, NM 87504-0968

Mr. William P. Stephens
Director
New Mexico Department of Agriculture
Office of the Director/Secretary
Box 3189
Las Cruces, NM 88003

North Dakota

Mr. James Fuglie
Information Officer
North Dakota Department of Agriculture
State Capitol
Bismark, ND 58505

State Entomologist
North Dakota Department of
Agriculture
State Capitol
Bismarck, ND 58505

Mr. Dave Nelson
Plant Protection Specialist
North Dakota Department of Agriculture
271 Hultz Hall
North Dakota State University
Fargo, ND 58105

Commissioner
State Game and Fish Department
2121 Lovet Avenue
Bismarck, ND 58501

Mr. Dale Naze
McKenzie County Agent
County Extension Service
Courthouse
Watford City, ND 58854

Ms. Joyce Byerly
Secretary-Treasurer
McKenzie County Grazing Association
211 North Main
Watford City, ND 58854

Mr. Walter Mattson
Golden Valley County Agent
County Extension Service
Courthouse
Beach, ND 58621

Oklahoma

Information Officer
Oklahoma State Board of Agriculture
122 State Capitol
Oklahoma City, OK 73105

Program Administrator-Plant Nursery
and Seed
Plant Industries Division
Oklahoma Department of Agriculture
2800 N Lincoln Boulevard
Oklahoma City, OK 73105

Director
Department of Wildlife Conservation
P.O. Box 53465
Oklahoma City, OK 73105

H. H. Coussens
Talihina Conservation District
Route 2, Box 459
Talihina, OK 74571

Oregon

Mr. John Valterza
Oregon Department of Agriculture
Agriculture Building
Salem, OR 97310

Mr. Bill Wright
Administrator
Plant Division
Oregon Department of Agriculture
Agriculture Building
Salem, OR 97310

Director
State Wildlife Commission
P.O. Box 3503
Portland, OR 97208

Mr. Don Tryon
Southeast Field Coordinator
Oregon Natural Resources Council
Southeast Field Office
P.O. Box 848
Bend, OR 97709

South Dakota

Information Officer
Anderson Building
South Dakota Department of Agriculture
Pierre, SD 57501

Mr. Michael W. McNamara
Emergency Assistance Analyst
Rural Development Programs
South Dakota Department of Agriculture
Anderson Building
Pierre, SD 57501

Mr. Jimmy Krsnak, Administrator
Plant Industry
Division of Regulatory Services
South Dakota Department of Agriculture
445 E Capitol-Anderson Building
Pierre, SD 57501

Department of Game, Fish, and Parks
State Office Building
Pierre, SD 57501

Texas

Information Officer
Texas Department of Agriculture
P.O. Box 12847
Austin, TX 78711

County Extension Entomologist
Tom Green/Runnels Counties of Texas
Texas Agricultural Extension Service
P.O. Box 658
Ballinger, TX 76821

Area Entomologist
Texas Agricultural Extension Service
6500 Amarillo Boulevard, West
Amarillo, TX 79106

Mr. James F. George
Environmental Affairs Department
El Paso Natural Gas Company
P.O. Box 1492
El Paso, TX 79978

Mr. L. N. Dexter
Texas Conservation Council, Inc.
11909 Knippwood Lane
Houston, TX 77024

Mr. Jim Hightower
Commissioner, Department of Agriculture
P.O. Box 12847, Capitol Station
Austin, TX 78711

Utah

State Entomologist-Division of Plant Industries
Utah Department of Agriculture
350 North Redwood Road
Salt Lake City, UT 84116

Utah Department of Natural Resources
Division of Wildlife Resources
1596 W. N. Temple
Salt Lake City, UT 84116

National Parks and Conservation Association
P.O. Box 1563
Salt Lake City, UT 84110

Mr. Edison Stephens
Deputy Commissioner
Utah Department of Agriculture
350 North Redwood Road
Salt Lake City, UT 84116

Mr. Paul Daniels
Director of Plant Industry
Utah Department of Agriculture
350 North Redwood Road
Salt Lake City, UT 84116

Mr. Alfred M. Rivas
Utah State Department of Agriculture
2576 Fillmore Avenue
Ogden, UT 84401

Ms. Carolyn Wright
Intergovernmental Coordinator
Office of Planning and Budget
Room 116 State Capitol
Salt Lake City, UT 84114

Washington

Supervisor-Washington Department of Agriculture
Chemical and Plant Services Division
406 General Administration Building AX41
Olympia, WA 98504

Washington Department of Fisheries
115 General Administration Building
Olympia, WA 98504

Washington Department of Game
600 N. Capitol Way
Olympia, WA 98504

Wyoming

Mr. Francis Petera, Assistant Director
The State of Wyoming Game and Fish Department
5400 Bishop Boulevard
Cheyenne, WY 82002

Mr. Walter H. Patch
Wyoming Department of Agriculture
2219 Carey Avenue
Cheyenne, WY 82002-0100

Mr. John Orton, Commissioner
Wyoming Department of Agriculture
2219 Carey Avenue
Cheyenne, WY 82002-0100

Mr. George F. Hittle
Wyoming Department of Agriculture
2219 Carey Avenue
Cheyenne, WY 82202

Agriculture Plant Industry Manager
Consumer-Compliance Division
Wyoming Department of Agriculture
2219 Carey Avenue
Cheyenne, WY 82202

Mr. John Larsen
OIC
Room 8004, U.S. Post Office and Courthouse
22nd and Capitol Streets
P.O. Box 667
Cheyenne, WY 82003-0067

Mr. Robert R. Benjamin
Supervisor
Sheridan County Weed and Pest Control District
P.O. Box 732 - Airport Road
Sheridan, WY 82801

Mr. Robert B. Shoemaker
Supervisor
Platte County Weed and Pest Control District
Box 775
Wheatland, WY 82201

Mr. Allen Mooney
Supervisor
Campbell County Weed and Pest District
Box 191
Gillette, WY 82716

ORGANIZATIONS AND CORPORATIONS

Ms. Becky Long
Alaska Survival
Box 344
Talkeetna, AK

American Agricultural Marketing Association
225 West Touhy Avenue
Park Ridge, IL 60068

Ms. Nancy Benson
American Cyanamid Company
1575 Eye Street, NW
Washington, DC 20005

Dr. William C. Jany
Product Development Manager
American Cyanamid Company
Agricultural Research Division
P.O. Box 400
Princeton, NJ 08540

American Farm Bureau Association
600 Maryland Avenue SE, Suite 800
Washington, DC 20024

American Farm Bureau Federation
225 Touhy Avenue
Park Ridge, IL 60068

American Forage and Grassland
Council
121 Dantzier Court
Lexington, KY 40503

American Institute of
Biological Sciences, Inc.
1401 Wilson Boulevard
Arlington, VA 22209

American Seed Trade Association
1030 15th Street, NW
Suite 964
Washington, DC 20005

American Sheep Producers
Council, Inc.
200 Clayton Street
Denver, CO 20005

American Society of Agronomy
677 South Segoe Road
Madison, WI 53711

Mr. Jack L. Prieur
Products Manager
Amvac Chemical Corporation
4100 East Washington Boulevard
Los Angeles, CA 90023

Ms. Linda S. Craig
Conservation Committee
Audubon Society of Portland
5151 Northwest Cornell Road
Portland, OR 97210

Mr. G. H. S. Hooper
Director
Australian Plague Locust Commission
Commonwealth Department of Primary
Industry
Industry House, Barton A.C.T. 2600
Australia

Ms. Beatrice Thys
Bendix Environmental Research
1390 Market Street
Suite 902
San Francisco, CA 94102

Mr. John Durham
BioTechnique Corporation
1944 Maple Avenue
Twin Falls, Idaho 83301

Center for Action on
Endangered Species
175 West Main Street
Ayer, MA 01432

Mr. Whitman Bassow
Center for International
Environmental Information
605 3rd Avenue
New York, NY 10017

Dr. Albert Fritsch
Center for Science in the
Public Interest
1757 S Street, NW
Washington, DC 10009

Mr. Michael Danley
Chevron Chemical
1 Crossroads of Commerce
Suite 1000
Rolling Meadows, IL 60008

Mr. Randy Morris
Chicken of the Desert Enterprises
P.O. Box 732
Mountain Home, ID 83647-0732

Ms. Georgia Hoglund
Citizens for Environmental Quality
Route 4, Box 158
Asotin, WA 99402

Ms. Angela Medbely
Colorado Environmental Coalition
2205 Meade Street
Denver, CO 80211

Ms. Janet Ocrowley
Chapter Chair
Committee for Idaho's High Desert
P.O. Box 664
Picabo, ID 83348

Mr. Samuel M. Hitt
Committee for Integrated
Pest Management
80 E. San Francisco
Santa Fe, NM 87501

Mr. Kirk Cunningham
Conservation Chairman
Sierra Club, Rocky Mountain Chapter
2239 East Colfax, #211
Denver, CO 80206

Mr. Louis Barassi
Defenders of Wildlife
1244 19th Street, NW
Washington, DC 20036

Dr. R. D. Carter
Del Monte Corporation
Box 36
San Leandro, CA 94577

Mr. Richard Munson
Environmental Action Foundation, Inc.
724 Dupont Circle Building, NW
Washington, DC 20036

Environmental Defense Fund
1525 18th Street, NW
Washington, DC 20036

Ms. Stephanie G. Harris
Research Associate
Environmental Defense Fund
2728 Durant Avenue
Berkeley, CA 94704

Ms. Bette Lou Fields
Environmental Studies Board
National Academy of Sciences
2101 Constitution Avenue, NW
Washington, DC 20037

Mr. John S. Evans
Evans BioControl, Inc.
P.O. Box 3266
Durango, CO 81302

Ms. Patricia M. Sobota
Editorial Department
Farm Chemicals
37841 Euclid Avenue
Willoughby, OH 44094

Grain and Feed Dealers National
Association
500 Folger Building
724 15th Street, NW
Washington, DC 20005

Mr. Tom Collazo
Huachuca Audubon Society
P.O. Box 63
Sierra Vista, AZ 85636

Idaho Farm Bureau Federation
P.O. Box 167
Boise, Idaho 83701

Mr. Tom Hamilton
Idaho Honey Producers Association
Rt. 7, Box 7213A
Nampa, ID 83651

Mr. Edwin Stockly
Idaho Natural Resources
Legal Foundation Inc.
P.O. Box 1946
Boise, ID 83701

Dr. Alberto R. Quisumbing
Director, Field Applications
Insecticide and Pheromone Products
Herculite Products, Inc.
1107 Broadway
New York, NY 10010

Izaac Walton League of
America, Inc.
R.R. 1
Metamora, IL 614548

Dr. Roger W. Ferenbaugh
Los Alamos Scientific Laboratory
P.O. Box 1663
Los Alamos, NM 87545

Mr. Wallace Caison
McKenzie County Grazing Association
P.O. Box 572
Watford City, ND 58854

Don Meike
Peter Meike and Sons, Inc.
Sussex Route
Kaycee, WY 82639

Mr. Steve Young
President
Mini-Cassia Grasshopper Committee
Desertview Farms
Route 3
Rupert, ID 83350

National Coalition Against the
Misuse of Pesticides (NCAMP)
530 7th Street, SE
Washington, DC 20003

National Agricultural Chemical
Association
Suite 514, Madison Building
1155 15th Street, NW
Washington, DC 20006

National Association of State
Departments of Agriculture
1616 H Street, NW
Washington, DC 20006

National Audubon Society
950 Third Avenue
New York, NY 10022

National Audubon Society
National Capitol Office
645 Pennsylvania Avenue, SE
Washington, DC 20003

National Cattleman's Association
Suite 300
1301 Pennsylvania Avenue, NW
Washington, DC 20004

Mr. Tony Dechant
National Farmers Union
P.O. Box 139251
Denver, CO 80239

National Grange
1616 H Street, NW
Washington, DC 20006

National Hay Association
P.O. Box 1059
Jackson, MI 49204

Ms. Terri Martin
Rocky Mountain Regional
Representative
National Parks and Conservation
Association
Box 1563
Salt Lake City, UT 84110

National Water Resources
Association
Suite 1202
955 L'Enfant Plaza, North, SW
Washington, DC 20224

National Wildlife Federation
1412 16th Street, NW
Washington, DC 20036

Newspaper Farm Editors of America
4200 12th Street
Des Moines, IA 50313

Ms. Norma Grier
Director
Northwest Coalition for
Alternatives to Pesticides
P.O. Box 1393
Eugene, OR 97440

Fred A. Slimp, II, Attorney
Pacific Legal Foundation
555 Capitol Mall, Suite 350
Sacramento, CA 95814

Pacific Legal Foundation, Inc.
1990 M Street, NW
Washington, DC 20036

Mr. Ralph Nader
Public Interest Research Group
2000 P Street, NW
Washington, DC 20036

Ms. Shirley A. Briggs
Executive Director
Rachel Carson Council, Inc.
8940 Jones Mill Road
Chevy Chase, MD 20815

Mr. Ed Britts
Regutech International Inc.
Two Greenwich Plaza
Suite 100
Greenwich, CT 06830

Mr. Julian McCaull
Scientists Institute for
Public Information
355 Lexington Avenue
New York, NY 10017

Dr. Edward Wayburn
Sierra Club
330 Pennsylvania Avenue, SE
Washington, DC 20003

Mr. J. Miller
Sierra Club
3145 David Avenue
Palo Alto, CA 94303

Sierra Club
530 Bush Street
San Francisco, CA 94108

Mr. Michael Gregory
Pest Management Coordinator
Sierra Club
Southwest Regional Conservation
Rt. 1, Box 25A
McNeal, AZ 85617

Rose Strickland
Chair, Sierra Club
Toiyabe Chapter - Nevada and
Eastern California
Las Vegas Group
P.O. Box 19777
Las Vegas, NV 89119

Mr. Jason Marks
Sierra Club Legal Defense Fund
1600 Broadway, Suite 1600
Denver, CO 80202

Society for Range Management
2760 West Fifth Avenue
Denver, CO 80204

Mr. William K. Reilly
The Conservation Foundation
1717 Massachusetts Avenue, NW
Washington, DC 20036

Dr. George M. Woodwell
President
The Ecosystem Center
Ecological Society of America
Marine Biological Center
Woods Hole, MA 02543

The Izaac Walton League
of America, Inc.
Suite 806, North Kent Street
Arlington, VA 22209

Mr. John E. Galley
The Nature Conservancy
P.O. Box 1346
Kerrville, TX 78028

T. Allen Scarborough
Union Carbide
P.O. Box 12014
Research Triangle Park, NC 27709

Mr. Kevin Glaeseman
Union Carbide
3305 Coyote Lane
Great Falls, MT 59404

Mr. Gerald Lorio
Union Carbide
P.O. Box 12014
Research Triangle Park, NC 27709

V. J. Ciccone and Associates, Inc.
14045 Jefferson Davis Highway
Woodbridge, VA 22191

Mr. Lonnie Williamson
Wildlife Management Institute
709 Wire Building
Washington, DC 20005

Mr. Ken Hamilton
Wyoming Farm Bureau

INDIVIDUALS

Mr. George Allen
P.O. Box 12773
Arlington, VA 20009

Mr. Rick Brown
3425 SW 12th Avenue
Portland, OR 97201

Mr. Evans W. Ferm
Box 55
Quemado, NM 87829

Mrs. Sally Gilliland
Ashland, MT 59003

Mr. Todd Graeff
2835 Harmony Street
Boise, ID 83706

Ms. Frances M. Green
4141 Arapahoe
Suite 200
Boulder, CO 80303

Ms. Rosemary Haley
P.O. Box C
Rupert, ID 83350

Mr. Philip H. Harvin
1730 Skyline Drive
Lincoln, NE 68506

Mr. John Hellandsaas
Box 525
Watford City, ND 58854

Ms. Lynn Herring
1090 Chandler Road
Lake Oswego, OR 97034

Mr. Dave Hirsch
1102 East Thayer
Bismarck, ND 58501

Mr. Dick Jackson
P.O. Box 723
Hermiston, OR 97838

Ms. Jackie Jacobson
201 Skyline Drive
Austin, TX 78746

Karen A. Jepson, M.A.
860 West Moorhead Circle, Apt. 2-J
Boulder, CO 80303

Mr. Buster McQueen
Rt. #1
Memphis, TX 79245

Ms. Becky Nichols
418 Campus Vista
Pullman, WA 99163

Ms. Carse Pustmneller
4150 Darley, Suite 5
Boulder, CO 80303

C. G. Spies
Box 239
Syracuse, NY 13201

Ms. Rose Strickland
1685 Kings Row
Reno, NV 89503

EDUCATIONAL INSTITUTIONS

Dr. J. B. Kendrick, Jr.
Director
Agricultural Experiment Station
317 University Hall
Berkeley, CA 94720

Ms. Karen Berke
Communications Coordinator
Agricultural Extension Services
385 University Hall
2200 University Avenue
Berkeley, CA 95616

Ms. Mary Bowen Hall
Agricultural Information
4415 Chemistry Annex
University of California
Davis, CA 95616

Mr. Falcon
Department of Entomology and
Parasitology
201 Wellman Hall
University of California
Berkeley, CA 94720

Mr. H. Cameron
Agriculture Information
401 Agriculture Sciences Phase II
Washington State University
Pullman, WA 99613

Dr. E. Paul Catts
Chairman
Department of Entomology
Washington State University
Pullman, WA 99164

Ms. Lesley Ann Foulsham
Library Service
College House, Wrights Lane
London W8 5SJ
England

Director
Agricultural Experiment Station
Colorado State University
Fort Collins, CO 80523

Mr. Fred Schmidt
Documents Librarian
Colorado State University
Libraries
Fort Collins, CO 80523

Mr. Gwil Evans
Chairman
Extension Communications
Administrative Services 422
Oregon State University
Corvallis, OR 97331

Ms. Debbie Miller
John Muir Institute
1307 Acton Street
Berkeley, CA 94706

Dr. William Olkowski
Co-Director
John Muir Institute
Center for the Integration of the
Applied Sciences
1307 Acton Street
Berkeley, CA 94706

Assistant Extension Editor
Kansas State University
Kansas Extension Service
Umberger Hall
Manhattan, KS 66502

Dr. F. W. Smith
Director
Kansas State University
Agricultural Experiment Station
Manhattan, KS 66506

Mr. Robert A. Walter
Government Documents
Pittsburg State University
Pittsburg, KS 66762-5889

Dr. J. A. Asleson
Director
Montana State University
Agricultural Experiment Station
Bozeman, MT 519717

Mr. Wendell Morrill
Montana State University
Department of Entomology
Leon Johnson Hall
Bozeman, MT 59717

Mr. J. Wayne Brewer
Montana State University
Department of Entomology
College of Agriculture
Bozeman, MT 59717-0002

Mr. Roger S. Peterson
Secretary
New Mexico Natural History
Institute
St. John's College Campus
Santa Fe, NM 87501

Extension Editor
New Mexico State University
Drawer 3A1
Las Cruces, NM 88001

Dr. L. S. Pope
Director
New Mexico State University
Agricultural Experiment Station
Las Cruces, NM 88003

Mr. F. C. Humphrey
Assistant Director,
Agriculture Communications
North Dakota State University of
Agriculture and Applied Science
Fargo, ND 58105

H. R. Lund
Director
North Dakota State University
Agricultural Experiment Station
Fargo, ND 58102

W. D. Valovage
Department of Entomology
North Dakota State University
Fargo, ND 58105

Dr. J. T. Schulz
Department of Entomology
202 Hultz Hall
North Dakota State University
Fargo, ND 58105

Mr. H. Paul Friesema
Center for Urban Affairs
Northwestern University
2040 Sheridan Road
Evanston, IL 60201

Oklahoma Academy of Science
c/o Southwestern Oklahoma
State University
North State Street, S-300
Weatherford, OK 73096

Oklahoma State University
Cooperative Extension Service
Division of Agriculture
Stillwater, OK 74074

Associate Director
Agricultural Experiment Station
Oklahoma State University
Stillwater, OK 74074

Head, Department of Entomology
Oklahoma State University
Stillwater, OK 74074

Dr. J. S. Davis, Director
Agricultural Experiment Station
Oregon State University
Corvallis, OR 97331

Assistant Professor and Chairman
of the Environmental Resource
Pennsylvania State University
101 Ferguson Building
University Park, PA 16802

Mr. Emmett R. Easton
Assistant Professor of Entomology
and Plant Science
South Dakota State University
Brookings, SD 57007

Dr. R. A. Moore
Director
South Dakota State University
Agricultural Experiment Station
Brookings, SD 57007

Mr. Dave Walgenbach
Plant Science Department
South Dakota State University
Brookings, SD 57007-0595

Dr. Peter J. Wilkin
Associate Professor
South Dakota State University
Box 2207
Brookings, SD 57007-0595

Agricultural Information Editor
South Dakota State University
University Station
Brookings, SD 57007

Texas A & M University
Department of Entomology
College Station, TX 77843

Texas A & M University
Department of Agricultural Information
Room 229, Reed McDonald Building
College Station, TX 77843

Texas A & M University
Agricultural Extension Service
College Station, TX 77843

Ms. H. Elizabeth Braker
Biology Department
The Colorado College
Colorado Springs, CO 80903

Dr. Steven G. Herman
The Evergreen State College
Olympia, WA 98505

Editor
University Communications,
Colorado State University
Colorado Extension Service
271 Aylesworth Hall
Fort Collins, CO 80521

Ms. Lorraine Kingdon
Agricultural Communications
University of Arizona
Tucson, AZ 85721

Dr. Dewhurst
Director
Agricultural Experiment Station
University of Arizona
Tucson, AZ 85721

Arthur L. Craignill, Ph.D.,
Extension Toxicologist
Environmental Toxicology and
Veterinary Extension
University of California, Davis
Davis, CA 95616

Ms. Maria Meneghin
Government Documents Department
University Library
University of California, Davis
Davis, CA 95616

Mr. M. William Stellmon
Editor
College of Agriculture
University of Idaho
Moscow, ID 83843

University of Idaho
Idaho Cooperative Fishery Unit, USDI
College of Forestry Wildlife
Management
Moscow, ID 83843

Dr. R. J. Miller
Director
Agricultural Experiment Station
University of Idaho
Moscow, ID 83843

University of Illinois
Documents Library
200-D Library
1408 West Gregory Drive
Urbana, IL 61801

University of Montana
Environmental Library
758 Eddy Street
Missoula, MT 59812

Dr. H. W. Ottoson
Director
Agricultural Experiment Station
University of Nebraska
Lincoln, NE 68503

University of Nebraska-Lincoln
Extension Information
Institute of Agriculture and
Natural Resources
Lincoln, NE 68583-0818

Dr. D. W. Bohmont
Director
Agricultural Experiment Station
University of Nevada
Reno, NV 89507

Mr. Larry Kirk
University of Nevada-Reno
Agricultural Communications
College of Agriculture
Reno, NV 89557

Gerry A. Day
University of Oregon
Environmental Studies Center
Eugene, OR 97403

University of Wyoming
Agricultural Experiment Station
University Station
P.O. Box 3354
Laramie, WY 82071

Mr. Everett W. Spackman
Cooperative Extension Service
University of Wyoming
P.O. Box 3354
Laramie, WY 82071

Mr. Jeffrey A. Lockwood
College of Agriculture
Department of Plant Science
University of Wyoming
P.O. Box 3354
Laramie, WY 82071

Dr. Robert E. Pfadt
College of Agriculture
Department of Plant Science
University of Wyoming
P.O. Box 3354
Laramie, WY 82071

Mr. Cleon Kotter
Chairman
Information Project
Utah State University
Logan, UT 84321

Dr. Howard Deer
Pesticide Coordinator
School of Graduate Studies
Center for Environmental
Toxicology
Utah State University
Logan, UT 84322-4620

Utah State University
Department of Biology, UMC 53
College of Science
Logan, UT 84322-5305

Dr. D. J. Mathews
Director
Agricultural Experiment Station
Utah State University of Agriculture
and Applied Science
Logan, UT 84322

Mr. Vincent J. Tepedino
Research Entomologist
Utah State University, UMC 53
Bee Biology and Systematics Laboratory
AR-SEA-USDA
Logan, UT 84322

Washington State University
Cooperative Extension Service
College of Agriculture
Pullman, WA 99164

NEWS MEDIA

Mr. Mark Warbis
Associated Press
Box 1187
Boise, ID 83701

Mr. Don Weberly
KBOI
Boise, ID

Ms. Lisa Balick
KBU-TV
P.O. Box 2
Boise, ID 83707

Mr. Tracey Curry
KGEM Radio
5601 Cassia
Boise, ID 83704

Mr. Terry McGren
KTVB
Boise, ID

Mr. Steve Ottesen
KTVB
Boise, ID

Mr. Jim Carlton
Farm Writer
Omaha World-Herald
World-Herald Square
Omaha, NE 68102

Mr. Jim Woolf
Salt Lake Tribune
P.O. Box 867
Salt Lake City, UT 84110

LaMar Bryan
Staff Writer
Northern Wyoming Daily News
723 Robertson Avenue
P.O. Box 508
Worland, Wyoming 82401

INDIAN AFFAIRS

Superintendent
Cheyenne Indian Reservation
Eagle Butte, SD 57625

Forrest Horn
Chairman
Crow Agency Indian Reservation
Crow Agency, MT 59022

Superintendent
Crow Creek Indian Reservation
Fort Thompson, SD 57339

Superintendent
Fort Belknap Indian Reservation
Harlem, MT 59526

Superintendent
Fort Peck Indian Reservation
Poplar, MT 59255

Superintendent
Fort Berthold Indian Reservation
New Town, ND 58763

Superintendent
Lower Brule Indian Reservation
Lower Brule, SD 57548

Carroll Barber
Land Operations
Office of Superintendent
J. Buffalohorn
North Cheyenne Indian Reservation
Lame Deer, MT 59043

Mr. Dan Spencer
Northern Cheyenne Indian Reservation
Lame Deer, MT 59043

A. Whirlwind Horse
Larry Hansen
Pine Ridge Indian Reservation
Pine Ridge, SD 57770

Superintendent
Rocky Boy Indian Reservation
Box Elder, MT 59521

Superintendent
Rosebud Indian Reservation
Rosebud, SD 57570

Southern Utes Indian Agency
P.O. Box 315
Ignacio, CO 81137

Superintendent
Standing Rock Indian Reservation
Fort Yates, ND 58538

Superintendent
Wind River Indian Reservation
Fort Washakie, WY 82514

OTHER

Director
Plant Health Division
Agriculture Canada
Ottawa, Ontario KIA 0C6
Canada

Mr. J. C. Arrand
British Columbia Ministry of Agriculture
808 Douglas Street
Victoria, British Columbia V8W 2Z7
Canada

Mr. Junko Katoh
Mitsubishi-Kasei
Institute of Toxicology and
Environmental Science
1000 Kamoshida-Cho, Midori-Ku
Yokohama 227
Japan

References Cited

Abdel-Rahman, M. S., D. W. Lechner, and K. M. Klein.
1985. Combination effect of carbaryl and malathion in rats. Archives of Environmental Contamination and Toxicology 14:459-464.

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1986. Malathion: a review of its toxicology and environmental fate. Princeton, NJ.

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Appendix A
Hazards of the Alternative Chemicals to Humans, Wildlife, and Aquatic Organisms

INTRODUCTION

To determine the potential hazard to various organisms from the three insecticides considered for use by APHIS--malathion, carbaryl, and acephate--this appendix presents a review of the available toxicological information on the three insecticides. Because carbaryl is commercially formulated (as Sevin 4-Oil) with petroleum oil and because diesel oil is used as a carrier in the application of Sevin 4-Oil, the hazards of petroleum oil and diesel oil are addressed as well. (Petroleum oils and diesel oil are listed by EPA as inerts of toxicological concern.) Although it is not currently used in APHIS control programs, the carbaryl formulation Sevin XLR Plus may be considered for future use, depending on the results of efficacy tests. EPA has classified the aqueous formaldehyde used us a preservative in Sevin XLR Plus as an inert of toxicological concern. The hazards of this formaldehyde constituent are thus presented in this appendix. Finally, the hazards associated with methamidophos, a degradation product of acephate, are analyzed in this appendix.

The first section of this appendix describes the sources of toxicity information used in the hazard analysis. The second section explains the terminology concerning laboratory toxicity testing used later in describing the toxic properties of the three insecticides. Scientific and technical terms are defined in the glossary (appendix E). The remainder of the appendix presents the hazards to humans, wildlife and beneficial insects, and aquatic organisms. Appendix B analyzes the amount of each insecticide that various organisms (including humans) are likely to be exposed to, and chapter 4 analyzes the risk to each organism, based on the results of the exposure analysis and the hazard levels that are detailed in this appendix.

SOURCES OF TOXICITY INFORMATION

The toxicity of the three insecticides to laboratory animals, humans, wildlife, and aquatic species is described in detail in the background statements prepared for APHIS by Roy F. Weston, Inc. (Dobroski, 1985; Dobroski and Lambert, 1984; Lambert, 1985). Much of the data on pesticide toxicity have been generated to comply with the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended (7 U.S.C. 136 et seq.), which establishes procedures for the registration, classification, and regulation of all pesticides, including insecticides. EPA is responsible for implementing FIFRA. Toxicity levels and related information from the series of studies submitted for registration are compiled by EPA in summary

tables, called "tox one-liners," that are available on request from EPA's Freedom of Information Office. EPA has compiled "science chapters" on carbaryl and acephate, and these are also available from EPA.

A large body of additional toxicity information exists in the scientific literature for all three chemicals. APHIS conducted an extensive literature search to ensure that all of the relevant available information was used in this risk analysis. The data from the APHIS background statements were reviewed and compared to summaries of studies submitted to EPA for the registration of the three insecticides. Whenever possible, studies that have been reviewed and evaluated by EPA were used to set toxicity reference levels. In no cases were studies used that have been determined invalid by EPA.

The Environmental Protection Agency will issue the "Guidance for the Registration of Pesticide Products Containing Malathion" in the fall of 1987. EPA has provided comments to APHIS concerning the toxicity of malathion, carbaryl, and acephate (U.S. EPA, 1986a), and those comments have been incorporated. Where EPA-reviewed studies on malathion were not available, studies from the scientific literature were cited. Data gaps identified by EPA in the registration of acephate and carbaryl are described in chapter 4.

HAZARD ANALYSIS TERMINOLOGY

Judgments about the potential hazards of pesticides to humans are necessarily based on the results of toxicity tests on laboratory animals. These toxicity test results are supplemented by information on actual human poisoning incidents and effects on human populations when they are available. The discussion of laboratory toxicity testing that follows is drawn from Doull et al. (1980), Hayes (1982), and Loomis (1978).

Laboratory Toxicity Testing

Test Animal Species

Laboratory test animals function as models of the likely effects of the pesticides in humans. Ideally, the test animal selected should metabolize the compound the same as a human would and should have the same susceptible organ systems. Results of such tests then can be directly extrapolated to humans with some adjustment made for differences in body weight and body surface area. Although no test animal has proven ideal, a number of species, in particular, rats, mice, rabbits, hamsters, guinea pigs, dogs, and monkeys, have proven to be consistent indicators for certain types of toxicity tests, routes of administration, and types of chemicals.

Toxic Endpoints and Toxicity Reference Levels

Toxicity tests are designed to produce specific toxic endpoints, such as fatality or cancer, and toxicity reference

levels, such as a no-effect level. In addition to the test animal used, toxicity tests vary according to test duration, route of administration, dose levels, dosing schedule, number of test groups, and number of animals per group. Toxicity tests also vary on the basis of whether it is assumed that the effect in question is a threshold effect or a nonthreshold effect.

Threshold and Nonthreshold Effects

Most chemicals are assumed to have a threshold level below which no adverse effects occur to the test organism. If the chemical is administered above the threshold level, however, adverse effects can occur. Such effects may be damage to a body tissue, a body dysfunction such as respiratory failure, or a toxic endpoint, such as birth defects. Chemicals are generally thought to possess no such threshold level for cancer and mutations; thus, these toxic endpoints may occur (with a certain level of probability) even in the presence of extremely small quantities of the substance.

Duration of Toxicity Tests

The duration of toxicity tests ranges from very short-term acute tests to longer subchronic studies to chronic studies that may last the lifetime of an animal. Acute toxicity studies involve administration of a single dose to each member of a test group (either at one time or in a cumulative series over a short period of usually less than 24 hours). Subchronic toxicity studies, used to determine the effects of multiple doses, usually last from a few days to several months (3 to 90 days), but generally less than one-half the lifetime of the test animal. Most common subchronic toxicity tests are 90 days. Chronic studies, also used to determine the effects of multiple or continuous doses, normally last 2 to 7 years, but generally more than one-half the test species' lifetime.

Routes of Administration

Routes of administration include oral via gavage (forced into the stomach with a syringe through a plastic tube) or fed in the diet; dermal (applied to the skin); inhalation (through exposure to vapors or aerosol particles); and parenteral (injection other than into the intestine), such as subcutaneous (injected under the skin), intraperitoneal (injected into the abdominal cavity), and intravenous (injected into a vein). Oral, dermal, and inhalation doses most nearly duplicate the likely routes of human exposure. Parenteral doses are used in testing drugs but are not widely used in toxicity testing of pesticides because they bypass the test animal's natural protective mechanisms.

Doses are expressed in several ways. They can be expressed as milligrams (mg, which is 1/1,000 of a gram) of the chemical per kilogram (kg, which is 1,000 grams) of body weight of the test animal. Or they can be expressed as parts per million (ppm) in the animal's diet, or in milligrams per liter (mg/L) in the air the animal breathes or in the water the animal drinks.

Dosing Levels

Dosing in longer term studies is generally done through the diet, with specified amounts in parts per million in the food. The known weight of the test animals over the test period is used to convert parts per million in the diet to milligrams of chemical per kilogram of body weight per day (mg/kg/day) for extrapolation to humans. Generally, at least three dosing levels are used in addition to a zero-dose or control group. Many times, a vehicle control is also included. Animals of each sex usually are dosed in groups of 8 to 50.

Types of Toxicity Studies

Acute Toxicity Studies

Acute toxicity studies are used to determine the toxicity reference level known as the median lethal dose (LD_{50}), which is the dose that kills 50 percent of the test animals. The lower the LD_{50}, the greater the toxicity of the chemical. The LD_{50} ranges and toxicity categories used in this risk assessment are those of the EPA classification system that uses rat LD_{50}'s, as shown in table A-1. Because mortality is the intended toxic endpoint, dose levels usually are set relatively high in acute studies. Toxic symptoms displayed by the animals are recorded throughout the study, and tissues and organs are examined for abnormalities at the end of the test. The animal most commonly used for oral LD_{50}'s is the rat. Rabbits are used most often to determine dermal LD_{50}'s.

Because death represents the extreme toxic consequence for judging possible effects from the use of pesticides, the policies of regulating agencies regarding acceptable intake levels of these chemical compounds are most often based not on acute studies, but rather on toxicity tests designed to find the dose level that produces no effects in the animal species tested. Figure A-1 illustrates the relationship between the LD_{50} and the no-effect level.

Subchronic Toxicity Studies

Subchronic studies are designed to determine the toxicity reference level called the no-observed-effect level (NOEL), which is the highest dose level at which no toxic effects are observed.

Table A-1--Acute toxicity classification and acute toxicities of the three insecticides

Toxicity category[1/] (label signal words)	Insecticide or other chemical substance	Oral LD_{50} for rats (mg/kg)	Equivalent human dose
IV Very slight		5,000 - 50,000 (range)	More than 1 pint
	Sugar	30,000	
	Ethyl alcohol	13,700	
III Slight (caution)		500 - 5,000 (range)	1 ounce to 1 pint
	Table salt	3,750	
	Bleach	2,000	
	Aspirin, Vitamin B_3	1,700	
	Acephate	866	
II Moderate (warning)		50 - 500 (range)	1 teaspoon to 1 ounce
	Malathion	370	
	Carbaryl	270	
	Caffeine	200	
I Severe (danger - poison)		0 - 50 (range)	1 teaspoon or less
	Nicotine	50	
	Strychnine (rodenticide)	30	
	Botulinus Toxin	0.00001	

1/Category, signal word, and LD_{50} ranges are based on a classification system used by EPA for labeling pesticides.

Source: Adapted from Maxwell, 1982.

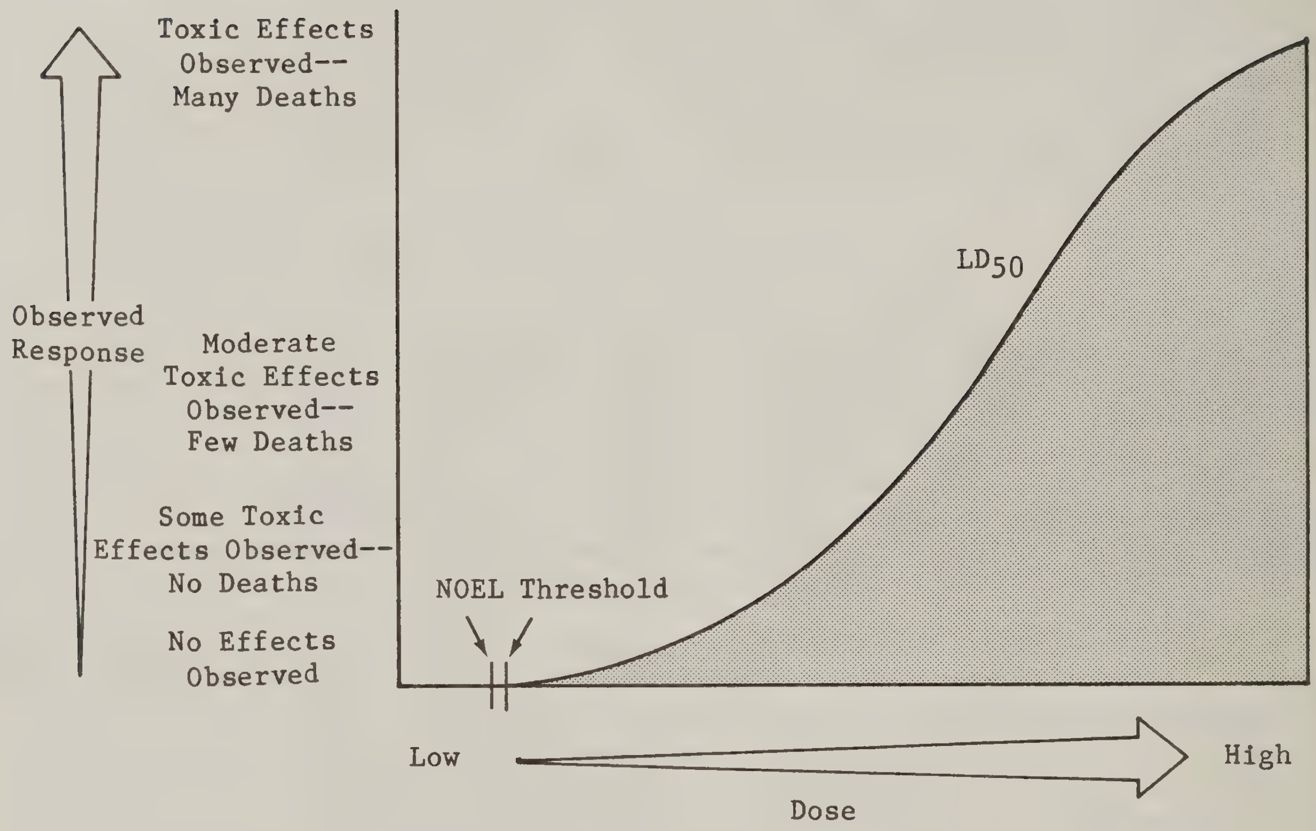

Figure A-1--Relationships among toxicity reference levels

Subchronic studies, normally employing lower dose levels than acute studies, provide information on systemic effects, cumulative toxicity, the latency period (the time between exposure and the manifestation of a toxic effect), the reversibility of toxic effects, and appropriate dose ranges to be used in chronic tests. The adverse effects may include decreased rate of food consumption; change in body weight; decreased enzyme levels; changes in blood constituents, such as red blood cells (RBC's) and white blood cells (WBC's); undesirable constituents in the urine; tissue pathology (gross or microscopic); or death.

Chronic toxicity studies. Chronic studies, like subchronic studies, can be used to determine systemic NOEL's. All other things being equal, the longer the study from which the NOEL is derived, the more confidence that can be placed in the predictive accuracy of the resulting value. Chronic studies, however, are even more important in determining doses that are hazardous to reproductive success or in determining whether the chemical causes cancer.

Teratogenicity tests. Teratogenicity tests (teratology studies) determine the potential of a chemical to cause malformations in an embryo or a developing fetus between the time of conception and birth. These studies are generally performed on rats or rabbits, and they may be conducted over several generations. The animals are monitored for functional as well as structural deformities.

Reproduction studies. Reproduction studies are conducted to determine the effect of the chemical on reproductive success as indicated by fertility (production of reproductive cells), fetotoxicity (direct toxicity to the developing fetus), and survival and weight of offspring. Other end points such as teratogenicity can be assessed, but these are the most common. These tests are performed at doses similar to those used in teratogenicity studies and generally use rats. Both male and female rats are exposed to the chemical for a number of weeks before mating. The number of resulting pregnancies, stillbirths, and live births are recorded. Tests may be conducted over two or three generations.

Carcinogenicity tests. Carcinogenicity tests examine the potential for a chemical to cause cancerous (malignant) tumors when fed in the diet over the animal's lifetime. Testing is normally conducted on rats or mice for approximately a 2-year period.

Mutagenicity Assays. Mutagenicity assays are used to determine the ability of a chemical to cause physical and biochemical changes (mutations) in the basic genetic material (DNA) that could be passed on from one generation to the next. The species used in these tests range from primitive organisms, such as the bacteria *Salmonella*, *Escherichia*, and *Streptomyces*; the mold *Aspergillus*; the yeast *Saccharomyces*; and the fruit fly *Drosophila*, to the more advanced organisms that include mammalian species. Tests may be conducted *in vivo* (within the body of the living organism) or *in vitro* (on cells cultured outside the body in a petri dish or test tube). There are many types of tests in this category, including the dominant lethal assay, which is usually conducted with rodents, and the Ames reverse mutation test, which is conducted with *Salmonella* bacteria.

HAZARDS TO HUMAN HEALTH

This section discusses the toxic hazards of the insecticides to humans as indicated by human epidemiological and clinical studies and by studies of effects in laboratory animals. The lowest reported toxicity values are summarized in table A-2.

Principal Toxic Effects of Organophosphates and Carbamates

This section summarizes Murphy's (1980) comprehensive discussion on the principal toxic effects of organophosphates and carbamates. The organophosphates (such as malathion and acephate) and carbamates (such as carbaryl) both exhibit

Table A-2--Laboratory-determined toxicity levels

Insecticide	Acute oral LD_{50} in rats	Lowest systemic NOEL	Lowest reproductive and/or teratogenic NOEL	Results of mutagenicity assays
Acephate	866 mg/kg (U.S. EPA, 1984c)	5 ppm (0.25 mg/kg/day), 28-month oncogenic rat study (U.S. EPA, 1982a)	No teratogenic effects in 2 studies with rats and rabbits. Teratogenic NOEL greater than 200 mg/kg/day, highest dose tested (U.S. EPA, 1984c)	Positive in mutagenicity assays using human and mammalian cells both *in vitro* and *in vivo*, and microbial cells *in vitro*.
			Maternal NOEL = 3 mg/kg/day, rabbit teratology study (U.S. EPA, 1984c)	Weakly positive in microbial assays. Negative results for human and mammalian cells *in vitro*, and *in vitro* and microbial cells (U.S. EPA, 1984c).
Carbaryl	270 mg/kg (U.S. EPA,1984a)	1.8 mg/kg/day, 1-year dog feeding study (U.S. EPA, 1984a)	Teratogenic NOEL of 3.125 mg/kg; maternal NOEL less than 3.125 mg/kg, dog teratology study (U.S. EPA, 1984a; Smalley et al., 1968)	Negative in an *in vivo* mammalian assay system (Epstein et al., 1972). Positive in chromosomal assays (U.S. EPA, 1984a)
			Teratogenic NOEL = 2 mg/kg; maternal NOEL less than 2 mg/kg, dog teratology study (U.S. EPA, 1984a)	
Malathion	370 mg/kg (NLM, 1986a)	0.2 mg/kg/day, 47-day human ingestion study (Moeller and Rider, 1962)	Reproductive and fetotoxic NOEL = 500 ppm (25 mg/kg/day), three-generation rat reproduction study (U.S. DHEW, 1976).	Negative in microbial assays and positive in an *in vitro* human cell assay (American Cyanamid Company, 1986).

Conversion Factor
Rat 1 ppm = .05 mg/kg/day

toxicity by inhibiting the activity of certain nerve transmission enzymes. These enzymes or cholinesterases (ChE's) include acetylcholinesterase (AChE) and function at nerve synapses to remove the choline (or acetylcholine) that conducts electrical impulses between nerve cells. The extent of inhibition of ChE caused by a given dose of insecticide is usually expressed as a percent; either a percent of normal activity or as a percent reduction compared to normal activity. The inhibition process is reversible. Organophosphates tend to inhibit ChE for longer periods than the carbamates at a given dose level, and the effects tend to accumulate, so that a sequence of low doses can produce the same effect as a single higher dose. Carbamates are relatively rapidly reversible ChE inhibitors. Organophosphates are generally metabolized in part to more active ChE inhibitors, for example, malathion to malaoxon; carbamates appear to function directly as inhibitors.

Toxic effects of ChE inhibition at low doses in humans include localized effects, such as nose bleed, blurred vision, and broncho-constriction; and systemic effects, such as nausea, sweating, dizziness, and muscular weakness. Effects of higher doses include irregular heartbeat, elevated blood pressure, cramps, and convulsions. In general, inhibition up to 40 percent (40-percent reduction in activity) in laboratory animals and humans is tolerated well and may produce transitory, less severe symptoms. Inhibition above 50 percent can lead to much more severe, prolonged symptoms of ChE inhibition. Where a fatal dose of organophosphates or carbamates has been received without emergency treatment (generally by administering the antidote atropine), death usually occurs within 24 hours.

Oral LD_{50}'s in rats for organophosphates range from 1.1 mg/kg (for TEPP) to 8,000 mg/kg (for Abate). Malathion's rat LD_{50} is 370 mg/kg; acephate's is 866 mg/kg. The human acceptable daily intake (ADI) for organophosphates ranges from 0.0025 mg/kg (.175 mg/day for a 70-kg human) for azinphosmethyl to 0.02 mg/kg/day (1.4 mg/day for a 70-kg human) for malathion. Rat oral LD_{50}'s for carbamates range from 0.8 mg/kg for Temik to 270 mg/kg for carbaryl.

For the organophosphates, other toxic effects, in addition to ChE inhibition, include delayed neurotoxic effects of phosphate triesters that include nerve cell demyelination and slow, but in general reversible, weakness and flaccidity of the limbs. Organophosphates are tested for this specific type of delayed neurotoxicity using hens.

Malathion

Acute Toxicity

Based on an acute oral LD_{50} (median lethal dose) of 370 mg/kg, malathion can be classified as a moderately toxic

insecticide (NLM, 1986a). The indicated LD_{50} of greater than 1,200 mg/kg is probably not unreasonable for the rat, but it is species dependent. For instance, in sheep the oral LD_{50} is less than 150 mg/kg; for the guinea pig, 570 mg/kg; for calves, 80 mg/kg; for cows 560 mg/kg; for hens 200-400 mg/kg; and for dogs, between 430 and 600 mg/kg.

Subchronic Toxicity

The major toxic effect observed in mammals after exposure to malathion is the inhibition of acetylcholinesterase resulting in the inhibition of nerve impulse propagation. Malathion itself is only slightly inhibitory; however, its metabolite malaoxon is an active inhibitor. In a study with mice, ChE activity was depressed by malaoxon 25 times more than by malathion (U.S. DHEW, 1976). Some studies indicate that conversion of malathion to malaoxon is necessary for any significant amount of anticholinesterase activity to occur. After absorption by the intestine, skin, or lungs, malathion is transported in the blood to the liver, where it is metabolized to nonacetycholinesterase inhibitors and to malathion's oxygen analog, malaoxon. Malathion and malaoxon are then rapidly detoxified by hydrolysis in the liver and other organs including the brain. The rapid hydrolysis and detoxification of malathion by the esterase enzyme system in humans accounts for its low toxicity in mammals (Dobroski and Lambert, 1984; U.S. DHEW, 1976).

A 33-day rat feeding study reported by EPA (1986a) found a ChE lowest effect level (LEL) of 1,000 ppm (50 mg/kg/day) for ChE inhibition in erythrocytes (red blood cells) and a ChE NOEL of 100 ppm (5 mg/kg/day). A 4- to 6-week rat feeding study during which males were fed 62 mg/kg/day of malathion and females were fed 68 mg/kg/day resulted in a 50-percent reduction of cholinesterase activity in the brain, plasma, and erythrocytes (Craigmill, 1981). Body weight reduction was reported as the only toxic effect observed in both 63-week and 68- to 70-week rat feeding studies (Craigmill, 1981). ChE activity was not determined in the 63-week rat feeding study.

A 47-day human ingestion study (Moeller et al., 1962) resulted in a lowest effect level for blood ChE inhibition of 0.40 mg/kg/day, and EPA has stated that this indicates a ChE NOEL of 0.2 mg/kg/day (U.S. EPA, 1986a). EPA has established an ADI of .02 mg/kg/day based on this study and a 10-fold safety factor.

Chronic Toxicity and Oncogenicity

A 2-year rat feeding study during which test animals were exposed to malathion at 100, 1,000, and 5,000 ppm (5, 50, and 250 mg/kg/day) resulted in a 10- to 30-percent reduction of ChE activity. At 5,000 ppm (the highest dose tested), growth

retardation, total inhibition of erythrocyte ChE, and a 60- to 95-percent inhibition of plasma and brain ChE was observed (U.S. DHEW, 1976).

A second 2-year rat feeding study during which animals were administered malathion at 500, 1,000, 5,000, and 20,000 ppm (25, 50, 250, and 1,000 mg/kg/day) also resulted in decreased ChE activity and body weight reduction. Histological examination of tissues revealed no anatomic lesions (U.S. DHEW, 1976).

The oncogenic potential of malathion and its metabolite, malaoxon, have been evaluated based on three bioassays that have been reviewed by EPA. An 80-week bioassay of mice and rats exposed to malathion did not result in evidence of increased tumor incidence (NCI, 1978). EPA (1986a) questions the negative conclusion with respect to mice. A second bioassay during which rats were administered 2,000 or 4,000 ppm (50 or 100 mg/kg/day) for 102 weeks did not result in tumor formation (NCI, 1979a). A third bioassay of the metabolite malaoxon also revealed no evidence of oncogenicity (NCI, 1979b).

A recent review by the National Toxicology Program (NTP) reevaluated studies on the carcinogenicity of malathion and its metabolite malaoxon (Huff et al., 1985). The review confirmed the original conclusion of the National Cancer Institute that malathion was not carcinogenic. However, NTP concluded that there was equivocal evidence of carcinogenicity for male and female F344 rats for malaoxon because of C-cell neoplasms of the thyroid gland. Consequently, theoretical lifetime cancer risks were calculated for malathion to estimate the maximum possible risk of carcinogenesis or mutagenesis. A cancer potency estimate of 0.02 $(mg/kg/day)^{-1}$ was used for the linear model, based on calculations by the California Department of Health Services (1980).

Reproduction and Teratology

The dietary administration of 240 mg/kg of malathion to rats for 10 weeks did not affect the reproductive performance of males or females (Kalow and Manton, 1961). EPA (1986a) concluded that the daily intake of 240 mg/kg of malathion reduced the number of newborn at 7 days of age by 50 percent. A three-generation reproduction study during which rats were fed 100, 500, or 2,500 ppm (5, 25, or 125 mg/kg/day) resulted in respiratory distress, reduced fertility, reduced pup weights, and poor survival of pups at the highest-dose-tested level of 2,500 ppm (125 mg/kg/day) (U.S. DHEW, 1976).

Mutagenicity

Malathion was nonmutagenic upon exposure to eight microbial assays (American Cyanamid Company, 1986). Malathion was

positive in human fibroblast cells in a sister-chromatid exchange assay (American Cyanamid Company, 1986).

Carbaryl

Acute and Subchronic Toxicity

Based on the acute oral LD_{50} for rats of 270 mg/kg, carbaryl can be classified as a moderately toxic insecticide (U.S. EPA, 1984a). The acute oral LD_{50} for dogs was reported to be less than 500 mg/kg; for monkeys it was found to be greater than 1,000 mg/kg (U.S. EPA, 1984a). The acute dermal LD_{50} for rats was reported to be greater than 4,000 mg/kg and to be greater than 5,000 mg/kg for rabbits (U.S. EPA, 1984a).

Acute and subchronic human exposure to carbaryl has been documented in poisoning reports, worker exposure studies, and volunteer ingestion studies. Ingestion of 2.8 mg/kg of carbaryl (Sevin formulation) resulted in epigastric pain and sweating. These effects were relieved by the administration of the antidote atropine sulfate (Harry, 1977). Ingestion of carbaryl at dose levels of 0.25, 0.5, 1.0, and 2.0 mg/kg by 10 volunteer subjects resulted in nausea and in vomiting in one test subject at the highest dose tested, but no toxic effects were observed at the other dose levels (Harry, 1977). Subacute dermal and inhalation exposure of carbaryl production workers at 0.44 to 4.9 mg/m^3 did not produce abnormal sperm count or infertility after a 1-year exposure period (U.S. EPA, 1984a).

Cholinesterase is instrumental in the normal propagation of nerve impulses because of its role in bond cleavage of the neurotransmitter acetylcholine. Subchronic and acute exposure to carbaryl has resulted in decreased cholinesterase levels and decreased reabsorption by proximal tubules of the kidney in humans. However, both of these toxic effects are transitory and have not resulted in permanent physiological damage to the exposed individuals (Harry, 1977; Wills et al., 1968). A subacute human ingestion study resulted in a NOEL of .06 mg/kg/day, with decreased amino acid reabsorption of the proximal kidney tubules observed at .12 mg/kg/day (highest dose tested) (U.S. EPA, 1984a). According to EPA (1986a), Wills et al. (1968) reported that "neither the plasma nor the calculated erythrocyte cholinesterase levels of the subjects underwent significant alteration." Dermal application of carbaryl (5 percent Sevin 85W) to 10 human test subjects resulted in depressed red blood cell cholinesterase levels after 24 hours; however, 5 days after exposure, the cholinesterase levels had returned to normal (Harry, 1977).

An acute oral cholinesterase LD_{50} rat study reported significant depression of plasma, red blood cell, and brain cholinesterase in the surviving test animals. A second acute oral cholinesterase study resulted in depression of the red

blood cell cholinesterase level in rats after exposure to carbaryl (in propylene glycol) at the dose of 12.5 mg/kg after 1 and 4 hours (U.S. EPA, 1984a). A 7-day rat cholinesterase study reported a NOEL of 10 mg/kg, with decreased levels of red blood cell cholinesterase at the lowest-observed-adverse-effect level (LOAEL) of 50 mg/kg (U.S. EPA, 1984a).

The administration of carbaryl to a variety of test species has resulted in transitory neurotoxic effects (weakness, incoordination). The subcutaneous administration of carbaryl to hens at the dose level of 2,000 mg/kg did not induce demyelination (U.S. EPA, 1984a). The administration of 150 and 300 mg/kg of carbaryl daily for 8 and 12 weeks did not result in skeletal muscle lesions due to delayed neurotoxicity (U.S. EPA, 1984a). Upon the histopathological evaluation of tissue sample reports from the above-mentioned studies, EPA has concluded that carbaryl does not pose a neurological hazard (U.S. EPA, 1984b).

A 6-week subacute human ingestion study (Wills et al., 1968) during which doses of 0.06 mg/kg and 0.13 mg/kg were administered daily resulted in no toxic effects at the lower dose level and a reversible decrease in the reabsorption capacity in the proximal tubule of the kidney at the higher dose.

Chronic Toxicity

A 1-year dog feeding study resulted in morphological changes in the kidneys of test animals but no apparent decrease in cholinesterase levels. The cholinesterase NOEL was reported to be greater than 7.2 mg/kg (highest dose tested) (U.S. EPA, 1984a). A systemic NOEL of 1.8 mg/kg and a LOAEL of 7.2 mg/kg were reported based on diffuse cloudy swelling or vacuolization of kidney cells (U.S. EPA, 1984a). Similar histological effects have been observed in the kidneys of rats and monkeys after exposure to carbaryl (Wills et al., 1968).

A 2-year rat feeding study reported a systemic NOEL of 200 ppm (10 mg/kg/day). At the highest dose level of 400 ppm (20 mg/kg/day), morphological changes characterized by cloudy swelling were observed within tubules of the kidney and hepatic cords of the liver (U.S. EPA, 1984a). No neoplastic changes were observed.

Teratogenicity and Reproduction

A study was conducted to evaluate the teratogenic potential of carbaryl administered by gavage or in the diet to mice and rabbits during days 6 through 15 and days 6 to 18, respectively, of gestation. Dietary administration to mice resulted in no teratogenic effects. A teratogenic NOEL for mice greater than 1,166 mg/kg/day (only dose tested) was reported

for dietary exposure, and a teratogenic NOEL greater than 150 mg/kg/day (highest dose tested) was reported for exposure by gavage. Fetotoxic effects in mice characterized by decreased maternal weight gain and reduced embryo development were observed at the dietary level of 1,166 mg/kg/day. A maternal NOEL less than 1,166 mg/kg/day was reported based on decreased weight gain. In the gavage study, decreased weight gain and cholinesterase inhibition were reported as maternal toxic effects. Administration of carbaryl by gavage to rabbits resulted in the establishment of a teratogenic NOEL of 150 mg/kg/day based on the occurrence of omphalocele (hernia of the navel). A dose of 200 mg/kg was reported as maternally toxic, and 150 mg/kg was reported as mildly maternally toxic when administered by gavage to rabbits (Murray et al., 1979).

A teratology study using guinea pigs, rabbits, and hamsters resulted in teratogenic effects in guinea pigs but no apparent malformations in hamsters and rabbits. Exposure of hamsters to carbaryl at levels of 125 to 250 mg/kg and rabbits at 50 to 200 mg/kg produced no teratogenic effects. In a study (Robens, 1969) that EPA (1986a) considers supplementary, teratogenic bone defects were observed in guinea pigs at the dose level of 300 mg/kg, though another teratology study that exposed guinea pigs to the same dose level produced no teratogenic effects (Weil et al., 1973).

A teratology study that exposed rats to dietary doses of up to 500 mg/kg/day of carbaryl did not result in teratogenic effects. Decreased weight gain was reported as both a fetal toxic and a maternal toxic effect at 500 mg/kg/day (Weil et al., 1972).

A three-generation reproduction study during which rats were exposed daily to carbaryl at 10 mg/kg did not significantly affect fertility, gestation, lactation, or viability of pups (Weil et al., 1972). A second three-generation rat reproduction study established a reproductive NOEL of 200 mg/kg (highest dose tested) when carbaryl was administered as part of the diet (Weil et al., 1973).

A teratology study during which beagle dogs were exposed to 50, 25, 12.5, 6.25, and 3.125 mg/kg of carbaryl throughout the gestation period resulted in a teratogenic NOEL of 3.125 mg/kg. Defects included abdominal fissures, failure of skeletal formation, absence of tail formation, and the presence of extra toes (Smalley et al., 1968).

The two teratology studies showing positive teratogenic effects in laboratory animals were classified by EPA as supplemental because they did not meet current scientific standards. During the exposure periods, the number of animals treated was insufficient, the condition of the females was not adequately

monitored, and the maternal and fetal blood levels were not adequately monitored in the treatment groups. According to EPA, "the extremely high doses of carbaryl used to elicit effects in the developing organism, coupled with the positive correlation of maternal and fetal toxicity in the multiple species tested (the dog being the possible exception), do not indicate that carbaryl constitutes a potential human teratogen or reproductive hazard under proper environmental usage" (U.S. EPA, 1984b).

Mutagenicity

A dominant lethal rat mutation assay indicated that carbaryl was nonmutagenic at the exposure level of 200 mg/kg (highest dose tested) (Epstein et al., 1972). However, chromosomal assays resulted in the induction of mitotic effects and chromosomal aberrations (U.S. EPA, 1984a). The reproductive effects assessment group of the Environmental Protection Agency has concluded that data from mutagenicity studies indicate that carbaryl does not act as a potent mutagen and can be classified as a weak mutagen (U.S. EPA, 1984b). EPA has concluded that carbaryl does not pose a mutagenic risk because only weak mutagenic responses have been measured and there is no evidence demonstrating the ability of carbaryl to reach germinal tissue so germ cells should not be affected (U.S. EPA, 1984b).

Oncogenicity

Despite speculation that carbaryl could combine with nitrite compounds to form a carcinogen under acidic conditions similar to those found in the human stomach, the majority of studies examining the carcinogenic potential of carbaryl have been negative. A preliminary report by the Carcinogen Assessment Group concluded that there was no significant increase in the incidence of tumor induction among treated animals relative to control animals (U.S. EPA, 1984a). The review of 10 chronic toxicity studies and the absence of significant tumor incidence at 400 ppm in rats and mice has provided sufficient evidence for EPA to conclude "that carbaryl is not oncogenic in experimental animals" (U.S. EPA, 1984b).

A 2-year oncogenicity rat feeding study was negative for carcinogenic effects at 400 ppm (20 mg/kg/day) (the highest dose tested) (U.S. EPA, 1984a). An oncogenicity mouse study during which carbaryl was either given orally at 464 mg/kg for 5 weeks, fed at 14 ppm (2.1 mg/kg/day), or administered under the skin in a single dose of 100 mg/kg did not induce cancer in test animals (U.S. EPA, 1984a). Another 2-year mouse oncogenicity study was negative at the dietary level of 400 ppm (60 mg/kg/day) (U.S. EPA, 1984a). An intraperitoneal oncogenicity study during which mice were administered carbaryl at a

dose level of 60 mg/kg/week produced no oncogenic effects in test animals (U.S. EPA, 1984a). The injection under the skin of 10 mg of carbaryl per week for a 20-week test period was negative for oncogenic effects (U.S. EPA, 1984a). The dermal application of a 57-percent water dilution of carbaryl resulted in no oncogenic effects (U.S. EPA, 1984a).

A 22-month rat feeding study at the dose level of 30 mg/kg (highest dose tested) resulted in the induction of malignant tumors in 4 of 12 surviving test animals (U.S. EPA, 1984a). Oncogenic effects also were observed after the subcutaneous administration of 20 mg of carbaryl to 48 rats; tumors formed in 2 of 10 surviving test animals. However, no significant increase in tumor incidence in treated groups relative to controls was found by the Carcinogen Assessment Group of the Environmental Protection Agency (U.S. EPA, 1984a). EPA (1986a) has stated that these two studies are supplementary because of the questionable purity of the test material.

Viral Enhancement

Interactions between viruses and chemical pesticides have been studied because of concern that these interactions may affect human health. This is of concern because of the suggested link between certain viral diseases and Reye's syndrome. The Maine Bureau of Forestry appointed a health advisory panel to review the data available on Sevin 4-Oil specific to viral potentiation; in January 1980, the panel released its findings and recommendations. The panel found that "there was a potential but inconclusive health risk of Sevin 4-Oil" on the basis of viral potentiation data available and recommended that the Maine Bureau of Forestry develop more stringent limitations so that "no uninformed, unconsented human exposure occurs during a forest spray operation."

Abrahamsen and Jerkofsky (1981) described the enhancing effect of Sevin 4-Oil on the replication of varicella-zoster virus (VZV) in cell culture and suggested possible implications of this interaction with regard to Reye's syndrome. Other more recent studies have raised questions and uncertainty about the Abrahamsen and Jerkofsky findings. EPA (1984b) has concluded "that the work of Abrahamsen and Jerkofsky was preliminary and did not constitute a basis on which to conclude that carbaryl poses a human hazard in terms of viral enhancement." Schmidt (1983) found that carbaryl treatment of host cell cultures delays the early spread of simian varicella viral infections. Schmidt suggested that the apparent effect seen by Abrahamsen and Jerkofsky occurred at a point in the growth cycle at which infectivity had reached maximum levels and was declining in untreated cultures, whereas the cells in the treated cultures, spared from early infection, had finally become infected. Schmidt also suggested that the proposed VZV-enhancing effect

of carbaryl and the possible implications to Reye's syndrome might be reevaluated.

In a recent study by Brookman et al. (1984), various insecticides, solvents, emulsifiers, and mixtures thereof were evaluated to determine whether any were capable of enhancing the sensitivity of cultured mammalian cells to infection with vesicular stomatitis virus. The investigation was replicated in three independent laboratories. None of the compounds, including the insecticide Sevin, significantly enhanced viral infection. This information, in addition to the study by Schmidt (1983), indicates that carbaryl does not significantly enhance viral infections.

N-nitrosocarbaryl Formation

Under acidic conditions similar to those found in the human stomach, carbaryl has been nitrosated in the laboratory to the reaction product N-nitrosocarbaryl (Eisenbrand et al., 1975). N-nitrosocarbaryl formation optimally occurs at a pH of 1.0. The pH of the human stomach increases to about 7.0 after a meal and then returns to the normal range of 1 to 2 within minutes (Cranmer, 1986). Very little N-nitrosocarbaryl formation occurs above the pH of 2.0 (Rickard et al., 1982). Elespuru et al. (1974) found that the combination of sodium nitrite (a food additive) with carbaryl in acid solution results in the formation of nitrosocarbaryl. It is thought that human exposure to N-nitrosocarbaryl could occur from the reaction of carbaryl residues (in food) with sodium nitrite (in saliva or food) in the acid conditions of the stomach.

N-nitrosocarbaryl has been characterized as a mutagen and a carcinogen based on positive laboratory studies (Eisenbrand et al., 1976; Elespuru and Lijinsky, 1973). An oncogenicity rat study resulted in the induction of malignant tumors at the injection site in 14 of 16 test animals after exposure to a dose level of N-nitrosocarbaryl at 1,000 mg/kg (Eisenbrand et al., 1975). Rats that were administered N-nitrosocarbaryl by gavage developed a high incidence of stomach tumors (invasive squamous carcinomas) (Lijinsky and Taylor, 1976). A rat feeding study also resulted in the formation of stomach tumors (Lijinsky and Schmahl, 1978). EPA (1986a) notes that "dietary levels fed to rats for the lifetime of the animal were without carcinogenic effects."

N-nitrosocarbaryl appears to be a much less effective inducer of mouse skin tumors than other methylating agents such as nitrosomethylurea. Dermal application of N-nitrosocarbaryl (25 microliters of a 0.04-moles-per-liter solution) to the shaved skin of 20 mice led to the induction of skin tumors at the site of application in 8 of the test animals, but only after repeated dermal applications (twice a week for 50 weeks)

to shaved skin. These tumors appeared in 1 of 20 animals at week 60, and in 8 of 20 by week 90 (Lijinsky and Winter, 1981). This indicates that N-nitrosocarbaryl could cause cancer in the stomach or on the skin if it could form in the environment as a result of carbaryl applications. However, the literature shows that N-nitrosocarbaryl can form only under conditions similar to those found in the human stomach--not in the air or on the skin. Thus, cancer risk from N-nitrosocarbaryl is considered only for oral exposure to the public.

A bacterial assay study characterized N-nitrosocarbaryl as a potent mutagen because of the positive mutagenic response of carbaryl in two bacterial systems (Escherichia coli and Haemophilus influenzae) (Elespuru et al., 1974).

Diesel Oil Toxicity

Sevin 4-Oil is formulated with petroleum products and diluted with diesel oil. Beck et al. (1982) conducted a short-term exposure study examining the acute toxicology of 19 petroleum hydrocarbons in acute oral, acute dermal, subacute dermal, and eye irritation studies. Based on an acute oral LD_{50} of 9.0 mL/kg (7,380 mg/kg)[1/], diesel oil can be classified as a very slightly toxic compound. The most marked acute toxic effect observed after the administration of diesel oil to test animals occurred during primary dermal irritation studies. A single diesel oil exposure to rabbits resulted in a rating of "extremely irritating" based on a score of 6.82 (on a scale of 1 to 10). Irritation may have been caused by additives for internal combustion in diesel oil. Diesel oil was nonirritating in primary eye irritation studies. A subacute 3-week dermal study of eight rabbits resulted in an average weight loss of .38 kg at the dose level of 4.0 mL/kg (3,280 mg/kg), and an average weight loss of .55 kg with a 67-percent mortality rate at the dose level of 8.0 mL/kg (6,560 mg/kg).

An inhalation teratology study in which rats were exposed to 101.8 ppm or 401.5 ppm (5.09 or 20.075 uL/kg) of diesel fuel on days 6 through 15 of gestation did not result in any significant teratogenic effects (Mecler and Beliles, 1979). Diesel fuel was nonmutagenic when tested in the Ames assay and the mouse lymphoma assay; however, it was found to be clastogenic (causing chromosomal breaks) in rat bone marrow cells (Conaway et al., 1982). Because diesel oil contains polycyclic aromatic hydrocarbons and other constituents that are known or suspected mutagens, it is considered to be a mutagen for this risk assessment.

[1/]One mL of diesel oil weighs 820 mg.

The oncogenic potential of petroleum fuels is directly related to refinery processing methods used to obtain the petroleum product and the crude oil composition from which the fuel was derived. An evaluation of the composition of petroleum fuels has revealed that a positive correlation exists between polycyclic aromatic hydrocarbon (PAH) content and carcinogenicity in human epidemiology studies or experimental laboratory studies (Bingham et al., 1979).

Diesel fuel is a complex variable mixture of hydrocarbons with a boiling point range of 350 to 700 °F and an aromatic content ranging up to 35 percent (U.S. DOE, 1983). Diesel fuel is usually a straight-run distillation product that boils below 650 °F, contains few polycyclic aromatics, and has not been shown to be carcinogenic. A 2-year oncogenic skin painting study, which was terminated after 62 weeks, during which Swiss Epley mice were exposed to .05 mL (41 mg) of diesel fuel products resulted in skin carcinomas in 2 of 50 animals, which was not statistically significant by chi-square analysis. The study was prematurely terminated because of the presence of extensive skin lesions in test animals (American Petroleum Institute, 1983). Higher boiling point (greater than 700 °F) petroleum products subjected to additional refinement processes such as cracking or hydrogenation and that contain polycyclic aromatics may be carcinogenic to experimental animals (Bingham et al., 1979).

Specific substances that are known or suspected of being carcinogenic, which are contained in diesel oil in small amounts, include benzo(a)pyrene and benzene. Benzo(a)pyrene (BaP), a potent carcinogen, is a PAH that also occurs at low levels in foods and in products of combustion, including cigarette smoke. Bioassays have indicated that the concentration of this single carcinogen can often serve as a guide in predicting carcinogenic potency, although other substances are also known to be involved (Bingham et al., 1979). There is sufficient evidence for the carcinogenicity of BaP in experimental animals: BaP has produced tumors in all of the nine species for which data have been reported following various methods of administration (U.S. DHHS, 1985). It has both a local and systemic carcinogenic effect. EPA has estimated the carcinogenic potency of BaP as 11.5 $(mg/kg/day)^{-1}$ (U.S. EPA, 1986b).

For benzene, another aromatic known to be present in diesel fuels, there is sufficient evidence for its carcinogenicity in experimental animals and in humans (U.S. DHHS, 1985). Benzene has been shown to cause leukemia in workers with chronic exposure. The carcinogenic potency of benzene, however, is much less than that of BaP. EPA has estimated the carcinogenic potency of benzene as 0.0445 $(mg/kg/day)^{-1}$ (U.S. EPA, 1986c). But benzene can occur at greater concentrations (approximately

29 ppm in No. 2 fuel oil) than BaP in diesel oil. Consequently, the carcinogenic potencies of diesel oil have been estimated for this EIS based on the potencies of both benzene and BaP.

Samples of diesel oil and fuel oil have been found to have a BaP content of only 26 ppb, but No. 2 heating oil (which may be subjected to cracking, rather than straight-run distillation) can contain 600 ppb (Bingham et al., 1979). The midpoint of this concentration range (313 ppb) has been used to calculate the carcinogenic potency of diesel oil, although most diesel fuels can be expected to have fewer BaP contents. The content of benzene in diesel fuel was assumed to be 28.5 ppm based on analysis of water extracts of No. 2 fuel oil by Anderson (1975), with corrections for solubility relationships. The resulting estimate of carcinogenic potency of diesel oil is 4.9×10^{-6} $(mg/kg/day)^{-1}$. Seventy-four percent of this potency is a result of the BaP component.

Formaldehyde Toxicity, Oncogenicity, and Other Effects

Although it is not currently used in APHIS control programs, the carbaryl formulation Sevin XLR Plus may be considered for future use, depending on the results of efficacy tests. EPA has classified the aqueous formaldehyde used as a preservative in Sevin XLR Plus as an inert of toxicological concern. EPA (1987) has recently proposed that formaldehyde when used as a preservative in a pesticide formulation should be classified as an active ingredient.) The hazards of this formaldehyde constituent are presented here.

The carbaryl formulation Sevin XLR Plus contains 0.3 percent of formalin as a preservative. The concentration of formaldehyde in the formalin is 37 percent; thus, the resulting concentration of formaldehyde in Sevin XLR Plus is $0.003 \times 0.37 = 0.0011$, or 0.11 percent.

Based on an acute, oral LD_{50} for rats of 800 mg/kg, formaldehyde can be classified as a slightly toxic pesticide (RTECS, 1986). Other reported LD_{50}'s are 270 mg/kg for guinea pigs; 42 and 660 mg/kg for mice (RTECS, 1986; HSDB, 1986).

Occupational exposure limits have been set for formaldehyde by several authorities. Exposure to formaldehyde used as an indoor fumigant, for example, in egg handling facilities and hospitals, is currently limited by EPA to 3 ppm (U.S. EPA, 1986d). The Occupational Safety and Health Administration (OSHA) has also set a limit of 3 ppm as an 8-hour time-weighted average, but a level of 1.0 or 1.5 ppm was proposed December 10, 1985, in 50 FR 50412. The exposure limit (TLV) currently specified by the American Conference of Governmental Industrial Hygienists is 1 ppm, as a time-weighted average.

Studies of the toxic effects of formaldehyde have been reviewed by the International Agency for Cancer Research (IARC, 1982) and by EPA during the preparation of the "Draft Guidance for the Reregistration of Products Containing Formaldehyde and Paraformaldehyde" (U.S. EPA, 1986d). The following paragraphs summarize some of the information and conclusions presented in those reviews.

The acute toxic effects of formaldehyde for humans include irritation of the eyes, nose, and throat leading to lachrymation (tearing), sneezing, shortness of breath, sleeplessness, tight chest, nausea, and excess phlegm. At a concentration of 0.1 to 3 ppm, most people experience irritation of the eyes, nose, and throat. (For comparison, the maximum concentration of formaldehyde in air in an area treated for grasshopper control will be less than 0.024 ppm.) Many people cannot tolerate exposure to 4 to 5 ppm over an extended period of time. More severe symptoms, including difficulty in breathing, are encountered if concentrations are 10 to 20 ppm. Serious injury to the respiratory tract may occur at concentrations greater than 50 ppm. However, at concentrations comparable to those that could occur as a result of grasshopper control (0.03 ppm), no irritation or other effects were observed (Weber-Tschopp et al., 1977).

Formaldehyde has been shown experimentally to be a potent allergen in humans. About 8 percent of male subjects exhibited skin sensitization after repeated occlusive applications of 1.8 or 3.7 percent formaldehyde for 3.5 weeks, and then an application of 1 percent 2 weeks later (Marzulli and Maibach, 1973). About 4 percent of the subjects in another study had allergic reactions to 0.8 percent formaldehyde applied under an occlusive patch (Rudner et al., 1973). Experiments indicate that most sensitized subjects can tolerate 0.003 percent formaldehyde solution applied to the armpit, but tests using occlusive patches indicate a greater sensitivity: one out of five sensitized subjects reacted to concentrations as low as 0.004 percent (Jordan et al., 1979; Marzulli and Maibach, 1973).

The effects of chronic exposure to formaldehyde include respiratory impairment and dermatitis.

EPA has classified formaldehyde as a probable human carcinogen (U.S. EPA, 1986d). It has been placed in Group B_1, which indicates sufficient evidence of carcinogenicity of a substance in experimental animals and limited evidence of carcinogenicity in humans. Formaldehyde has been found to be carcinogenic by inhalation in two strains of rats, and there is evidence of potential carcinogenicity in mice (U.S. EPA, 1986d). There is also evidence that formaldehyde may promote tumor formation when administered in drinking water to rats (U.S. EPA, 1986d).

EPA (1986d) has reviewed 28 epidemiological studies of formaldehyde exposure and found that formaldehyde may be a human carcinogen, but the evidence was classified as limited because exposures to multiple chemicals may confound the findings of excess cancers.

EPA (1986d) calculated a unit cancer risk of 1.3×10^{-5} corresponding to an exposure of 1 ug/m^3 of formaldehyde over a 70-year period. EPA (1986d) also calculated the corresponding cancer risk for agricultural workers subject to high exposure levels of formaldehyde used as a preservative in agricultural pesticides. Assuming 0.3 percent formaldehyde in the formulation, a 40 year worklife, and exposure from mixing, loading, one boom sprayer application and 4 airblast sprayer applications per year, the cancer risk was estimated not to exceed 1 in 1 million (1×10^{-6}). The risk is primarily because of dermal exposure. The risk from the inhalation component was estimated to be in the range of 1 chance in 10^{-7} to 10^{-8}.

Data from mutagenicity tests of formaldehyde were reviewed by the Consensus Workshop on Formaldehyde. They concluded that formaldehyde acts as a weak mutagen. However, none of these data are acceptable to EPA for regulatory purposes (U.S. EPA, 1986d). EPA has requested gene mutation, structural chromosomal aberration, and other genotoxicity tests.

Inhalation studies in animals and epidemiological studies in workers have not demonstrated teratogenic effects. However, these studies were not considered adequate by EPA, and additional studies have been requested (U.S. EPA, 1986d). A reproductive study showed prolonged diestrus but no impairment of reproductive function. The reproductive study also was considered inadequate by EPA, and a two generation rate reproduction study has been requested.

Acephate

Acute Toxicity

Based on an acute oral LD_{50} in rats ranging from 866 mg/kg (females) to 945 mg/kg (males), acephate can be classified as a slightly toxic insecticide (U.S. EPA, 1984c). An acute delayed neurotoxicity study did not produce leg paralysis in hens exposed to 785 mg/kg/day, which was the only dose tested (U.S. EPA, 1984c). The acute dermal LD_{50} for rabbits was reported to be greater than 10,000 mg/kg (U.S. EPA, 1984c).

The acute dermal LD_{50} for rabbits exposed to the 75-percent spray formulation of acephate was greater than 10,250 mg/kg (highest dose tested) (U.S. EPA, 1984c). An acute inhalation study of rats resulted in no deaths or toxic symptoms at 12.1 mg/L/hr (only dose tested) for the Orthene 75S formulation of acephate (U.S. EPA, 1984c).

Acute laboratory testing conducted to evaluate the toxicity of the acephate impurity methylthioacetate (MTA) has demonstrated a potential hazard to the optic tracts and pituitary glands of mammals. An acute dermal study of rabbits exposed to dose levels of 1,500, 2,000, 2,500, and 3,000 mg/kg of methylthioacetate resulted in a nonreversible diminution or absence of the pupillary light reflex and blindness due to optic tract and pituitary gland damage (U.S. EPA, 1985). Additional dermal exposure studies have not resulted in the visual impairment of test animals. EPA has requested further testing to determine the toxic and mutagenic potential of methylthioacetate.

Subchronic Toxicity

The organophosphate acephate is a cholinesterase-inhibiting insecticide that produces transitory reversible effects at low doses in a variety of vertebrate species. The predominant toxic effect seen in test animals after exposure to acephate is a decreased activity of red blood cell, plasma, and brain cholinesterase.

An in vitro cholinesterase inhibition assay using red blood cell membranes or brain tissue homogenates of the rat, monkey, and human resulted in poor inhibition of acetylcholinesterase and cholinesterase activities in all test species when compared with eserine, the positive control (U.S. EPA, 1984c). A 21-day rat feeding study resulted in a NOEL of less than 30 ppm (1.5 mg/kg/day); 30 ppm was the lowest dose tested and resulted in a 21-percent inhibition of red blood cell cholinesterase during the second test week and a 15-percent inhibition during the third test week (U.S. EPA, 1984c). A 21-day dermal rabbit study resulted in 51 to 54 percent inhibition of red blood cell cholinesterase at dose levels of 0.5, 1.0, and 2.0 g/kg for the Orthene 75S formulation (U.S. EPA, 1984c). A 33- to 34-day oral cholinesterase study during which monkeys were exposed to acephate (2.5 mg/kg body weight) resulted in a 50-percent reduction of plasma, red blood cell, and brain cholinesterase activities, and a 5- to 17-percent reduction in the activity of cerebrospinal cholinesterase (U.S. EPA, 1984c).

Chronic Toxicity and Oncogenicity

A provisional acceptable daily intake (PADI) level of .0025 mg/kg/day has been established for the inhibition of cholinesterase activity, based on the NOEL of 5.0 ppm (0.25 mg/kg/day) derived from a chronic (28-month) rat feeding study and using a safety factor of 100 (U.S. EPA, 1985).

A 2-year validated Industrial Bio-Test dog feeding study established a systemic NOEL greater than 100 ppm (2.5 mg/kg/day) based on the absence of toxic systemic effects; however, a cholinesterase NOEL of 30 ppm (0.75 mg/kg/day) was reported

with reduced activities in red blood cell, plasma, and brain observed at 100 ppm (2.5 mg/kg/day) (U.S. EPA, 1984c).

Histopathological examination of tissue specimens from a 28-month oncogenic rat feeding study revealed no evidence of carcinogenic effects at the highest dose level, which was 700 ppm (35 mg/kg/day) (U.S. EPA, 1982a).

A 2-year oncogenic study during which mice were exposed to 1,000 ppm (150 mg/kg/day) of acephate resulted in a 15.8-percent incidence of liver tumors (hepatocellular carcinomas) and a 19.7-percent incidence of excessive noncancerous cell growths (hyperplasic nodules) in females. At this dose level, weight alteration was observed in the livers, kidneys, brain, and ovaries, and decreased body weight gain was also observed. Liver and lung injuries were observed at all testing levels (U.S. EPA, 1984c).

The occurrence of liver tumors in female mice has been classified by EPA as limited evidence of carcinogenicity upon evaluation of the following factors: liver tumors occurred only at the highest dose tested (150 mg/kg/day) with no substantial dose-related increase in malignant tumor incidence; no evidence of tumor metastasis was observed; tumors occurred only in female mice; and tumor incidence was observed only at the end of the study. In accordance with proposed EPA guidelines for carcinogenic risk assessment (Federal Register, November 23, 1984), EPA has concluded from this evidence that acephate is a weak carcinogen. Therefore, with the use of protective clothing and required label specifications, EPA believes that there will be no unreasonable adverse effects from using products containing acephate (U.S. EPA, 1985). However, a theoretical cancer risk assessment is presented in chapter 4.

Teratogenicity

Teratogenic effects have not been induced in laboratory animals upon maternal exposure to acephate during gestation. A validated Industrial Bio-Test rat teratology study reported a teratogenic NOEL greater than 200 mg/kg (highest dose tested) (U.S. EPA, 1984c; U.S. EPA, 1982a). A rabbit teratology study also resulted in a teratogenic NOEL greater than the highest dose level tested (10 mg/kg); however, a maternal toxic NOEL of 3 mg/kg was reported based on increased nasal discharge and increased incidence of spontaneous abortion (U.S. EPA, 1984c).

Mutagenicity

Acephate was positive when tested in an unscheduled DNA synthesis assay in human fibroblastic cells, mitotic crossing-over and gene conversion assays in yeast cells, the CHO (Chinese hamster ovary) cell cytotoxicity assay, bacterial recombination

assays, bacterial reverse gene mutation assays, bacterial mitotic crossing-over assays, bacterial gene conversion assays, gene mutation assays in mammalian cells, and the sister chromatid exchange assay in CHO cells (U.S. EPA, 1984c). Weakly positive results were reported on the exposure of acephate to bacterial mutagenicity assays and the bacterial Ames assay (U.S. EPA, 1984c). Negative results were reported for the *in vivo* mouse micronuclei assay, the bacterial Ames assay, the dominant lethal mouse *in vivo* assay, the *in vivo* cytogenetic mouse bone marrow cell assay, sister chromatid exchange, and chromosomal aberration assays of monkeys and mice (U.S. EPA, 1984c). Both weakly positive and negative results were reported for a second unscheduled DNA synthesis assay in human fibroblast cells (U.S. EPA, 1984c).

According to EPA (1985), "The overall conclusion is that acephate has a definitive effect in a number of mutagenic assays. The *in vivo* assays, which were without response, are generally regarded to be of lesser activity; nonetheless, these negative effects show that acephate is not a strong mutagenic agent under *in vivo* conditions, while moderately mutagenic in cellular systems (prokariots [sic] and eukariots [sic])." This risk assessment assumes acephate is a weak mutagen with a risk of mutations no greater than that computed for cancer.

Methamidophos

Toxicity of the Metabolite Methamidophos

Acephate is metabolized in mammalian systems to methamidophos, a relatively more toxic compound that is a registered insecticide itself. Up to 10 to 29 percent of applied acephate is transformed to methamidophos in other animals, plants, and environmental media (see appendix B).

Acute Toxicity

Based on acute oral LD_{50} values of 13 to 15.6 mg/kg in rats, methamidophos is classified as very toxic by EPA (1982d). A lower oral LD_{50} of 7.5 mg/kg for rats was reported in the Registry of Toxic Effects of Chemical Substances (RTECS) (1987). As illustrated in table A-3, which gives LD_{50} values for various mammals, methamidophos is 10 to 70 times more acutely toxic than acephate.

Methamidophos was very toxic when applied dermally to rabbits based on an LD_{50} of 118 mg/kg (U.S. EPA, 1982d). Although methamidophos is considered a mild skin irritant, it was readily absorbed through the skin and was lethal to 55 to 67 percent of the rabbits studied.

The lowest toxic dose reported for humans is 257 mg/kg (RTECS, 1987). Toxic signs were observed in the peripheral nervous

Table A-3--Comparative oral toxicity of acephate (Orthene) and methamidophos (Monitor)

	LD_{50} (mg/kg body weight)	
Animal tested	Acephate	Methamidophos
Mouse	150-361	14
Rat, Male (Sprague Dawley)	945-1,100	15.6
Rat, Female (Sprague Dawley)	866	13
Rabbit	700	10
Guinea Pig	--	30

Sources: Lambert, 1985; RTECS, 1987.

system, eyes, and skin. Toxic effects similar to those reported for other organophosphates would be expected.

Subchronic Toxicity

In a 90-day dog feeding study, a systemic NOEL of 0.375 mg/kg was established (U.S. EPA, 1982d). The lowest effect level was 0.125 mg/kg based on ChE inhibition in plasma and red blood cells.

Humans ingesting 256 mg/day for 5 days or 64 mg/day for 4 weeks exhibited no symptoms or detectable effects on plasma and red blood cell ChE activity (HSDB, 1987). In a 73-day study in humans, a NOEL of 0.1 mg/kg/day was reported based on ChE inhibition in red blood cells after ingestion of a 1 to 4 mixture of methamidophos to acephate. For a 1 to 9 mixture of methamidophos to acephate, a NOEL of 0.2 mg/kg/day was determined (U.S. EPA, 1982d). The dose of methamidophos would be 0.02 mg/kg/day for either NOEL (1/5 of 0.1 mg/kg/day or 1/10 of 0.2 mg/kg/day).

Chronic Toxicity

Two-year chronic feeding studies reported no signficant effects in dogs fed 0.75 mg/kg/day and in rats fed 10/mg/kg/day (HSDB, 1987).

A mouse oncogenic study in progress reported no compound-related trends in body weights, food consumption, hematology, gross necropsy, behavioral abnormalities, or toxic symptoms at

doses of 1, 5, or 25 ppm (0.15, 0.75, and 3.75 mg/kg, respectively) methamidophos (U.S. EPA, 1982d).

Teratogenicity and Reproduction

Methamidophos was not embryotoxic or teratogenic to rabbits at 2.5 mg/kg, which was the highest dose tested (U.S. EPA, 1982d). However, maternally toxic effects were observed at all levels (0.1, 0.5, and 2.5 mg/kg), based on decreased weight gain.

Mutagenicity

In a dominant lethal assay with mice, intraperitoneal injection of 1 and 2 mg/kg did not result in mutagenic effects. Results of *in vitro* studies with several strains of bacteria were also negative (U.S. FDA, 1980). Additional mutagenicity testing is required according to EPA (1982d).

Oncogenicity

Methamidophos was not oncogenic in a rat-feeding study at 3, 10, and 30 ppm (U.S. FDA, 1980). Additional testing is required according to EPA (1982d).

NOEL and ADI levels were not established by EPA (1982b) because of data gaps. The Food and Drug Administration (1980) reported an ADI by FAO/WHO of 0.002 mg/kg/day.

WILDLIFE HAZARD

Malathion

Acute Toxicity

Malathion is moderately toxic to mammals and moderately to slightly toxic to birds. The lowest oral LD_{50} for rats is 370 mg/kg. The relative toxicity of malathion among mammals is shown in table A-4. The acute dermal LD_{50} in rats is 4,444 mg/kg (NLM, 1986a). The inhalation LC_{50} in rats has been reported to be greater than 60 mg/L (U.S. EPA, 1975).

The oral LD_{50} for chickens is 150 mg to 850 mg/kg (U.S. EPA, 1975). The oral LD_{50} is 167 mg/kg for pheasants and 403 mg/kg for the horned lark (Hudson et al., 1984). The LD_{50} in mallards is 1,485 mg/kg. Signs of intoxication that appeared at lethal and near-lethal doses included ataxia, walking high on toes, imbalance, hypoactivity, wing-drop, weakness, slowness, sitting, ptosis, falling with wings spread, tenesmus, salivation, swallowing, tremors, dyspnea, and convulsions (Hudson et al., 1984).

Table A-4--Acute oral toxicity of malathion in mammalian species

Animal tested	LD_{50} (mg/kg)
Rabbit	53
Dairy Calves	80
Rat	370
Guinea Pig	570
Mouse	775

Source: NLM, 1986a.

Field Studies and Subchronic Toxicity

Field studies indicate that there are no significant impacts to wildlife in areas treated with malathion, although a concern for acetylcholinesterase inhibition exists. ULV sprays at 1 to 10 times the labelled application rates of malathion did not produce any detectable neurotoxic symptoms (ChE was not depressed), and food consumption was normal in bobwhite quail (Joseph et al., 1972). No adverse effects or behavioral changes were noted in any wildlife species in 4,300 acres of meadow in Utah treated at 0.5 lb a.i./acre (Henderson, 1967). This application rate is only slightly less than the 0.58 lb a.i./acre (8 oz a.i./acre) proposed for use in the grasshopper control program.

No effects on wildlife were observed via population censuses, carcass counts, and tissue residue analysis in areas sprayed at 6.8 oz a.i./acre of malathion (McEwen et al., 1972).

A study in Michigan found no significant adverse effects on birds and mammals in areas sprayed with malathion at 1 lb a.i./acre. Caged pheasants held in the area showed no adverse effects and no effects were observed in necropsied birds (U.S. DOI, 1963). In Texas, cotton fields were repeatedly treated with malathion at 12 oz to 16 oz a.i./acre. No effects on birds were noted in wildlife areas adjacent to the fields. Caged quail held among treated rows of cotton also showed no effects (Sinclair, 1968).

Areas in Nebraska treated for grasshopper control at 8 oz a.i./acre of malathion showed no significant impacts on birds or mammals. However, domestic turkeys that were held in cages in treated areas and allowed to feed on insects from the treated area had slightly depressed plasma ChE levels, but no external symptoms were noted (USDA, 1985).

Birds in a forested watershed that had been treated with 0.7 lb a.i./acre of malathion appeared noticeably quiet for a 2-day period after the spraying. This may have been the result of acetylcholinesterase inhibition, which has been directly related to a decrease in physical activity. No other effects were observed (Dobroski and Lambert, 1984).

Malathion at extremely high doses has been shown to decrease brain AChE in quail and mallards (Dobroski and Lambert, 1984). Although malathion appears to reduce brain ChE and AChE levels, the minimum application rate to cause this effect has not yet been determined. Further research in this area has been suggested by the U.S. Fish and Wildlife Service (1986).

Effects on Reproduction

Reproductive effects of malathion have been studied in chickens. Birds were exposed to increasing amounts of malathion in their feed for 29 weeks. Doses were 100 mg/lb of feed for 4 weeks, 200 mg/lb of feed for 3 weeks, and 500 mg/lb of feed for 22 weeks. Test results indicated reduced weight gains and a 25-percent mortality of test birds. Egg production was not affected (U.S. EPA, 1975). In another study with chickens, no reduction in hatchability of eggs was observed after 2 years of exposure to 2,500 ppm of malathion in feed (U.S. EPA, 1975).

Hen eggs injected with malathion in acetone at 25, 100, 200, 300, 400, and 500 ppm killed 15, 13, 38, 29, 58, and 94 percent of embryos, respectively (Dunachie and Fletcher, 1969). Teratogenetic effects were caused, especially when combined with ethion in a 3 to 1 ratio. In another study, eggs injected with 2.5 mg each of malathion and carbaryl did not hatch (Ghassemi et al., 1981).

Other Effects

The discussion in the human health hazard section of this appendix provides details on the chronic toxicity, oncogenicity, teratogenicity, and mutagenicity of malathion.

Effects on Beneficial Insects

As a broad spectrum pesticide, there is little, if any, selectivity between the toxicity of malathion to target pests

and to beneficial insects on the same plant (Dobroski and Lambert, 1984).

Honey Bees. Malathion is highly toxic to bees and can cause severe losses if bees are present at the time of treatment with this pesticide. Damage to bee populations can be considerably reduced by timing the application to avoid exposing bees to freshly applied malathion. The 48-hour LD_{50} in honey bees (*Apis mellifera* L.) is 0.709 ug/bee for exposure to malathion dust (Atkins et al., 1973).

Treatments while bees are foraging in the field are usually the most hazardous. Furthermore, application over colonies in hot weather when bees are clustering on the outside of the hives may result in severe losses. Treatments during night and early morning before bees are foraging are safest. Usually, injury is not significant to colonies one-quarter mile or more from treatments unless the treated field is the only attractive crop in the area. The farther the colonies are from the treatment area, the less critical the treatment time. Colonies moved into the field 2 or 3 days after treatment usually escape damage (Dobroski and Lambert, 1984).

Residual action of ultra-low-volume (undiluted) application of malathion on bees exhibits four times greater toxicity than that usually encountered following dilute applications. Pesticide applications by aircraft have been shown to be more hazardous than application by ground equipment. Granular application has been shown to be the safest method of treatment for bees (Dobroski and Lambert, 1984).

Bees collecting pollen from treated areas may be killed in great numbers when walking over treated surfaces, but an equally significant danger lies with the pollen itself. Older bees (normally the worker bees) are less susceptible to malathion and may carry contaminated pollen back to the hive before they sicken and die. Young and reproductive members of the colony that eat the pollen also may die. Once in the hive, the contaminated pollen may remain toxic for months. However, if bees are removed beyond flight range from an area to be sprayed and not returned for 3 days, mortality is not significant. Most recommendations include moving the colony for a brief period or confining the bees to their hive prior to and shortly after spraying (Dobroski and Lambert, 1984).

Parasitic and Predatory Insects. Malathion is toxic to such beneficial parasites and predators as ladybird beetles and parasitic wasps. A study of beneficial insect populations was conducted over 4 years where repeated applications of 12 oz a.i. and 16 oz a.i. malathion were made annually. The applications resulted in an adverse effect on lady beetles, scymnus beetles, hooded beetles, softwinged flower beetles, and lace-

winged beetles immediately following the application. However, the researchers found no major differences in the spring populations of beneficial insects (Huddleston et al., 1968).

Investigations of malathion application suggest that certain insect orders are more susceptible than others. Observations of the effects of low-volume aerial application of malathion for mosquito control showed that the insect orders Homoptera (cicadas, leafhoppers, and the like) and Hemiptera (the true bugs) declined during the treatment period, whereas other insect orders, including Diptera (the flies) with the exception of family Culicidae (the mosquitoes), were not affected. Many insects in the order Hymenoptera (bees, wasps, ants, and the like) seemed to be especially susceptible to malathion (Dobroski and Lambert, 1984).

Another study of the effects of malathion applications (8 oz a.i) to nontarget leafhoppers indicated only one of five monitored species failed to recover to control area population levels within 2 weeks after treatment. The one species, *Scaphytopius acutus* (Say), was suppressed from one growing season to the next. Malathion is registered as a means of controlling leafhoppers under certain crop conditions.

Reductions in beneficial predator wasps and parasites are only temporary because of the short-lived residues of malathion (Manser and Bennet, 1963).

Carbaryl

Acute Toxicity

Carbaryl is considered moderately toxic to mammals and slightly toxic to birds. The acute oral LD_{50} of carbaryl ranges from 150 mg/kg to 710 mg/kg for mammalian species and from 780 mg/kg to more than 2,500 mg/kg for avian species (Ghassemi et al., 1981; Hudson et al., 1984; NLM, 1986b). Carbaryl is used on poultry, cattle, and pets to control insect pests. Acute oral LD_{50}'s for mammals and birds are shown in table A-5.

The LD_{50} is greater than 2,564 mg/kg for mallards. Toxic symptoms observed in birds at lethal or near-lethal doses include inactivity, ataxia, regurgitation, weakness, fluffed feathers, salivation, slowness, lethargy, tachypnea, tremors, ataraxia, tetany, paralysis, coma, and convulsions (Hudson et al., 1984).

Field Studies and Subchronic Toxicity

Mammals. Carbaryl is registered for ectoparasite control on dogs, cats, and livestock (Union Carbide, 1986).

Table A-5--Acute oral toxicity of carbaryl in mammalian and avian species

Animal tested	LD_{50}[1/] (mg/kg)
Mammals	
Cat	150
Rat	250
Mouse	275
Mule Deer[2/]	200 to 400
Rabbit	710
Birds	
Mallard	>2,564
Pheasant	>2,000
Rock Dove	1,000-3,000
Chukar	(1,498-2,378)
Japanese Quail	2,290 (1,740-3,020)
Sharp-Tailed Grouse	780-1,700
Canada Goose	1,790 (1,480-2,180)[3/]

[1/]Numbers in parentheses are the 95% confidence intervals.
[2/]Female, age = 11 months.
[3/]50% carbaryl.

Sources: NLM, 1986b; Hudson et al., 1984; Ghassemi et al., 1981.

Several studies have examined the effects of carbaryl on wild populations of small mammals with varying results, according to appliction rates. The proposed rate for this program is 0.5 lb a.i./acre (8 oz a.i./acre) of carbaryl, which is lower than any of the reported studies. In Canada, no changes were observed in small mammal populations 2 months after spraying forested areas with carbaryl for spruce budworm control (Buckner et al., 1973). A study of an area in New York treated with 1.25 lb a.i./acre of carbaryl reported no adverse effects on small mammals or deer (Connor, 1960).

Denisova (1973) reported a decrease in mole and rodent populations in forests treated with carbaryl at a high rate (4.46 lb per acre). No recovery of populations was reported within 2 years. Tissue residues of carbaryl in males were 5

mg/kg in reproductive organs, 3 mg/kg in liver, and 1.5 mg/kg in muscle.

Barrett (1968) reported a decline in cotton rat populations, an increase in house mouse populations, and no change in old field mouse populations following treatment of a millet field at 2 lb a.i./acre of carbaryl. Carbaryl residues in millet were 35 ppm. There was a 4-week delay in the reproductive cycle of the cotton rat. Laboratory studies by Barret supported these findings. Doses of 1.1 mg/adult/day (similar to those in the field study) resulted in a greater than 50-percent decline in the number of female cotton rats giving birth and in the total number of litters. At the same dose, reproduction in the house mouse was not affected.

Birds. Results of carbaryl studies on birds vary. A number of studies have reported no effects on bird populations in areas treated with carbaryl. Several studies have reported decreased levels of ChE activity. One study has reported significant declines in bird populations possibly resulting from reduced food supplies.

The following studies showed no adverse effects at application rates at least two times that of the rate proposed for APHIS' grasshopper control program (0.5 lb a.i./acre). In New York, an area was treated with carbaryl at a rate of 1.25 lb a.i./acre. No effects were observed on behavior, reproduction, or rearing of young in 49 species of birds (Connor, 1960). Following carbaryl spraying, no significant effects were observed on nesting success, total number of breeding birds, mortality rates, or brain ChE levels (Zinkl et al., 1977). Richmond et al. (1979) reported a similar lack of adverse effects to birds in Oregon after applications of 2.0 lb a.i./acre of carbaryl. No adverse effects were reported in birds in Colorado at a rate of 1.0 lb a.i./acre (McEwen et al., 1962). Bart (1979) reported no changes in bird populations or song frequency in forest plots treated at 1 lb and 5 lb of carbaryl per acre. No changes in songbird populations occurred up to 3 weeks after spraying Canadian spruce forests at 1 lb carbaryl per acre (Buckner et al., 1973).

A decrease of brain cholinesterase in forest birds in Montana was measured after applications of carbaryl at 1.0 lb a.i./acre (Zinkl et al., 1977). The authors suggested that observed depressed ChE levels may reduce a bird's ability to avoid predators and to obtain food. Another study reported no decrease in ChE levels in birds in Maine forests treated at 0.31 lb and 0.69 lb per acre (Gramlich, 1979). Knowledge is lacking regarding the minimum application rate of carbaryl that causes ChE depression. Further research is needed in this area to more accurately assess impacts on wildlife.

Forested areas in New Jersey treated in the month of June for gypsy moth control with carbaryl at 1 lb/acre resulted in a 55-percent decrease in bird populations within 2 weeks after spraying and showed no recovery during 6 more weeks of monitoring or in the following year during June and July (Moulding, 1972). The unsprayed plot showed no significant changes. It was noted that canopy species were more affected than ground feeders. The author suggested the following possible explanations for the overall decline of birds: opportunistic feeding outside the sprayed area, possible reduced reproductive success, or a shift in nest-site loyalty, all of which may be a result of reduced insect populations and food supply. Doane and Schaefer (1971) have suggested that the removal of gypsy moth larvae, which is an important food source for birds, could cause migration of birds out of treated areas.

Diesel and Petroleum Oils

Toxicity

The use of Sevin 4-Oil diluted with diesel oil would result in the dispersion of a low dosage of petroleum oils into the environment. Sevin 4-Oil contains nonaromatic, low volatile oils (Union Carbide, 1984) with a flash point of 88 °C (Union Carbide, 1978). Diesel oil contains 25 to 40 percent aromatics and has a flash point of 85 °C (U.S. DOE, 1983).

The acute oral LD_{50} of diesel oil for mallard ducks older than 1 year is greater than 20 mL/kg (Tucker and Crabtree, 1970). However, traces of oil in a mallard's diet sharply reduce egg production (Biderman and Drury, 1980). Furthermore, application of 5 uL of No. 2 fuel oil on eggs reduced hatching success to 18 percent (Szaro et al., 1978); pheasant eggs sprayed with diesel oil to runoff failed to hatch (Kopischke, 1972).

Studies sponsored by the American Petroleum Institute (1982) showed no adverse clinical symptoms in rabbits at 5 mL/kg diesel oil applied dermally. An oral LD_{50} of 9.0 mL/kg (7,380 mg/kg) was determined for rats. A dose of 16,000 mg/kg diesel oil force-fed to rabbits was sublethal (USDA, 1979). In a subacute dermal absorption study, 4 out of 6 rabbits died at a dose of 8 mL/kg diesel oil (American Petroleum Institute, 1982). At both 4 and 8 mL/kg, acute dermal corrosion was observed, and at 8 mL/kg, hepatic toxicity was seen.

The major hazards of Sevin 4-Oil and diesel oil application to wildlife include trace amounts of oil clinging to feathers or fur of birds or mammals, possibly leading to death by hypothermia through loss of insulation, or to loss of flight in birds; reduced reproduction and hatching success in avian species; and sublethal effects in small mammals from contaminated forage (American Petroleum Institute, 1983).

Effects on Reproduction

Studies indicate the possibility that extensive use of carbaryl may cause a significant reduction in reproductive success of avian species, especially quail and pheasant. DeRosa et al. (1976) found residues of carbaryl in yolks of Coturnix quail eggs produced 8.5 hours after treatment levels similar to those encountered in the field. Fecal analysis indicated carbaryl residues were no longer present at 52 hours. Exposure to a second treatment caused significant reduction in egg production in direct proportion to treatment levels. Egg viability was not affected; however, agonistic behavior was decreased in males but increased in females following pesticide ingestion. DeRosa et al. suggested that these behavioral modifications may disrupt pair formation in the field, thereby jeopardizing the bird's reproductive success.

DeWitt and Menzie (1961) reported a reduction in chick production of quail when fed diets containing a total of 12,000 mg/kg or more of carbaryl during growth, winter, and production periods. Pheasants fed diets with 500 or more ppm carbaryl during the breeding season had a 50-percent reduction in chick survival. Depressed body weights were observed in quail fed diets containing 250 ppm or more carbaryl and in pheasants fed diets containing 1,000 ppm carbaryl. The percentage of growth depression in pheasants was roughly proportional to the daily intake of carbaryl.

Japanese quail fed 50, 150, 300, 600, 900, and 1,200 mg carbaryl per kg of feed from the day of hatching to 14 weeks of age showed growth depression and increases in relative brain, liver, and kidney weights (Bursian and Edens, 1977). A slight decrease in egg production and viability was observed at the 600, 900, and 1,200 levels.

Zinkl et al. (1977) also suggested that brain cholinesterase inhibition caused by treatment with 1 lb a.i./acre carbaryl may result in reduced reproductive success through inability of birds to gather food or escape predation.

In a study involving exposure of eggs to pesticides, 40 percent of eggs injected with 5 mg of carbaryl hatched (Ghassemi et al., 1981). No eggs hatched that were injected with 2.5 mg each of malathion and carbaryl. These dosages are considered to be well above the expected environmental exposure. In another study, hen eggs injected with 100 and 200 ppm carbaryl in acetone killed 61 and 100 percent of embryos, respectively (Dunachie and Fletcher, 1969). Teratogenic effects were caused at 50 ppm and above.

Other Effects

Refer to the discussion in the human health hazard section of this appendix for details on the chronic toxicity, oncogenicity, teratogenicity, and mutagenicity of carbaryl.

Effects on Honey Bees

Carbaryl is very toxic to honey bees (Union Carbide, 1980). In honey bees, the 48-hour LD_{50} for direct exposure is 1.34 ug/bee for carbaryl dust and 1.02 ug/bee for Sevin 4-Oil dust (Atkins et al., 1973). Similar results were reported by Stevenson (1970). The LD_{50} for an adult bee by direct contact was approximately 1 ug or 10 to 15 mg/kg.

Carbaryl is more toxic to honey bees when ingested than from direct contact. The results of laboratory experiments indicate that the LD_{50} is 0.18 ug per bee when administered by the oral route (Alvarez et al., 1970). Bees collecting pollen from treated areas may be killed in great numbers when walking over treated surfaces (Mayland and Burkhardt, 1970).

Older bees (normally the worker bees) are less susceptible to carbaryl (Mayland and Burkhardt, 1970) and may carry contaminated pollen to the hive before they sicken and die. The young and the reproductive members of the hive also may die from eating pollen (Johansen and Brown, 1972; Mayland and Burkhardt, 1970; Strang et al., 1968). Once inside the hive, the contaminated pollen may remain toxic for months (Johansen and Brown, 1972; Moffett et al., 1970).

If bees are removed beyond flight range from an area to be sprayed and not returned for 7 days after spraying, mortality is not significant (Atkins et al., 1975, 1977; Strang et al., 1968; Union Carbide, 1981). Another method to reduce the effects of spraying carbaryl near bees is the deliberate feeding of corn pollen to the bees, which seems promising on an experimental basis (Moeller, 1972). Most recommendations include either moving the colony for a brief period or confining the bees to their hive prior to and shortly after spraying (Agriculture Research Service, 1967, 1977).

Effects on Other Insects

Because carbaryl acts as a broad spectrum pesticide (U.S. EPA, 1980), a certain amount of toxicity to a wide variety of insects and other arthropods may be expected. Many insects in the order Hymenoptera (this order includes the honey bees) seem to be especially susceptible to carbaryl (Abu and Ellis, 1977; Adams and Cross, 1967; Plapp and Vinson, 1977; Stern, 1963).

Ladybird beetles (coccinellid) also have been found to be very sensitive to carbaryl (Afify et al., 1970; Bartlett, 1963, 1966; Colburn and Asquith, 1971; Satpathy et al., 1968; Stern et al., 1959). In general, both groups of insects are regarded as beneficial insects because they act as predators and parasites of various insect pests in crops. Comparatively less carbaryl is required to kill these beneficial insects than is needed to kill pest insects. Even parasites developing inside a treated host insect may be killed (Abu and Ellis, 1977), as will ladybird beetles feeding on poisoned aphids (Satpathy et al., 1968). A loss of these predators may occur in carbaryl-treated areas, but no permanent loss has been found in monitored spray programs (Root and Skelsey, 1969; Shepard and Sterling, 1972; Union Carbide, 1980). A fairly rapid reestablishment of these beneficial insects by immigration from areas surrounding the treated area can be expected because little residual effect of carbaryl exists several days after spraying.

Carbaryl is not toxic to all members of the order Hymenoptera because at least one important pollinator of alfalfa, the alfalfa leafcutting bee, is only moderately susceptible to carbaryl (Johansen et al., 1963; Waller, 1969). Other beneficial insects, such as the predaceous big-eyed bugs (Walker et al., 1974) and green lacewings (Plapp and Bull, 1978) are not severely affected by carbaryl (Union Carbide, 1980).

Effects on Spiders and Mites

Spiders are not severely affected in carbaryl-treated fields (Shepard and Sterling, 1972), although they have been shown to be more sensitive to carbaryl when they ingest treated prey than when they walk over treated surfaces (Hagstrum, 1970). As shown in another study, spiders quickly return to treated areas within 3 weeks after spraying (Barrett, 1968).

Carbaryl is highly toxic to predatory mites but not as toxic to phytophagous (plant-feeding) mites (Bartlett, 1968; Dabrowski, 1969, 1970; Dabrowski et al., 1973). One investigation (Croft and Jeppson, 1970) showed that carbaryl was less toxic to predaceous mites than was previously reported in the literature. Mite predators, such as the predaceous thrips, are also susceptible to carbaryl (Holdsworth, 1968; MacPhee and Sanford, 1961). This difference in toxicity to mite predators may cause detrimental outbreaks of phytophagous mites, which are common in cotton.

Acephate

Acute Toxicity

Acephate is slightly to moderately toxic to birds and mammals. The lowest oral LD_{50} for the rat, reported for the technical formulation, is 866 mg/kg (U.S. EPA, 1984c). An oral LD_{50}

of 707 mg/kg was reported for rabbits exposed to a formulation of 75 percent acephate (Orthene 75S) (U.S. EPA, 1984c). Rabbits had an acute dermal LD_{50} of greater than 10 g/kg when exposed to the technical formulation and greater than 10.25 g/kg (highest dose tested) when exposed to a 75-percent acephate spray formulation (U.S. EPA, 1984c). Acute inhalation studies with rats have reported LC_{50}'s of greater than 61.7 mg/L/4 hours (only dose tested) for 97-percent technical formulation and greater than 12.1 mg/L/1 hour (only dose tested) for Orthene 75S (U.S. EPA, 1984c).

Hens had a reported oral LD_{50} of 360 mg/kg (304 mg/kg to 425 mg/kg) (U.S. EPA, 1984c). The oral LD_{50} for mallards is 234 mg/kg. Toxic symptoms that occurred when mallards were given lethal or near-lethal dosages included (in approximate order of onset): ataxia, imbalance, hopping and falling, jerkiness, mild spasms in the legs and feet, immobility, wing spreads, and intermittent tremors (Hudson et al., 1984). Through revised labels, EPA (1985) will restrict the use of acephate in areas of rangeland and pastureland where it may jeopardize endangered and threatened avian species.

Field Studies and Subchronic Toxicity

Mammals. Brain cholinesterase depression has been reported for small mammals following aerial spraying of acephate (0.5 lb a.i./acre) on forest plots in Idaho. Red squirrels recovered within 6 days after spraying, but Columbian ground squirrels had depressed cholinesterase levels at 25 days after spraying (Zinkl et al., 1980). Recovery of stressed individuals, such as pregnant or nursing animals, could be somewhat slower. The application rate for APHIS' cooperative control program is 0.094 lb a.i./acre (1.5 oz a.i./acre) on acephate.

Birds. In field studies, results on the effects of acephate on bird populations differ. Although no significant effects were observed in some areas, others showed significant declines in population numbers thought to be related to reduction in food supply. In addition, significant ChE inhibition was observed in several cases.

Songbird populations sprayed with acephate at rates of 0.09 to 6.5 lb a.i./acre were not adversely affected at two sites in eastern Canada. Surveys were performed for up to 6 days after spraying to detect changes in songbird populations and to identify dead or ill birds (Buckner and McLeod, 1975).

A significant decline in red-eyed vireos occurred following treatment with acephate of a forested plot in New York at a rate of 0.5 lb a.i./acre. Whether the decline was a direct result of the pesticide or a result of a decline in the birds' food supply was not determined (Bart, 1979).

Two vireo species abandoned treated areas, and singing activity of the crested flycatcher decreased after areas were sprayed with acephate. These reactions were considered responses to arthropod food supply distribution (LOTEL, 1975).

No direct mortality of wildlife was observed after aerially applying acephate at 1.5 oz a.i./acre (this is the same as the application rate for grasshopper control) on rangeland in Wyoming, Utah, and Arizona in 1979 and 1980, and in Wyoming in 1981 (McEwen and DeWeese, 1981). However, birds and small mammals did exhibit reduced brain cholinesterase activity in live specimens taken up to 24 days after spraying. The effects of sublethal brain cholinesterase reduction are largely unknown, but the literature indicates that the long-term biological and population effects may not be very great for depressions of less than 25 percent of brain cholinesterase. Potential short-term effects, however, could include inability to gather food, to escape predation, or to adequately care for young.

A number of other studies have reported significant depression of brain cholinesterase in songbirds following spraying of acephate at rates of 0.5 lb to 2.0 lb a.i./acre (Julin and Gramlich, 1978; Zinkl et al., 1977; Zinkl et al, 1980; Richmond et al., 1979). These rates are all well above that proposed for use by APHIS.

Studies by Zinkl et al. (1981) with dark-eyed juncos and by Fleming and Bradbury (1981) with mallards indicated that brain cholinesterase depression of greater than 50 percent may be fatal. The latter study also concluded that there appears to be a threshold dose for acephate (and other organophosphate pesticides) that must be surpassed before inhibition of brain cholinesterase occurs. However, this threshold application rate has not yet been determined, and research has been suggested by the U.S. Fish and Wildlife Service (1986).

Recovery from acephate exposure also can be monitored by measuring brain cholinesterase over time. Recovery to about 80 percent of normal cholinesterase levels occurred within 10 days in bobwhite quail and mallards after 2 weeks on diets with 20 ppm acephate (Stelzes, 1982). However, recovery of nesting birds, which would already be stressed, may be somewhat slower.

Lambert (1985) summarized in his review of the literature that "forest applications of acephate at recommended rates of 0.5 and 1.0 lb a.i./acre can be expected to produce physiological indications of organophosphorus intoxication in forest birds." The proposed application rate for the grasshopper control program of 1.5 oz a.i./acre is considerably less than these

rates. Lambert also stated that recovery from sublethal doses of acephate appears to take only a few days.

Effects on Reproduction

Avian reproduction studies showed no reduction in mallard egg production with 16-week diet exposures of 5, 20, and 80 ppm technical acephate (Beavers et al., 0029691 as cited in U.S. EPA, 1984d). However, duckling survival, up to 14 days of age, was reduced 20 percent at the 20- and 80-ppm levels; no effects were observed at the 5-ppm level. In bobwhite studies, egg production and chick survival were both significantly reduced at the 80 ppm level but were not affected at the 5- and 20-ppm treatment levels (Beavers et al., 0029692 as cited in U.S. EPA, 1984d). In both studies, observed AChE inhibition increased with dosage and may suggest a basis for reduction in reproductive output.

Peterson et al. (1981) reported no decrease in nesting success of rangeland birds on plots sprayed with 0.1 lb a.i./acre acephate.

Other Effects

Refer to the discussion in the human health hazard section of this appendix for details on the chronic toxicity, oncogenicity, teratogenicity, and mutagenicity of acephate on birds and mammals.

Effects on Honey Bees, Wild Bees, and Other Pollinators

Acephate is highly toxic to honey bees. The 48-hour LD_{50} for topical exposure to acephate dust is 1.20 ug/bee for honey bees (Aphis mellifera L.) (Atkins et al., 1973). Laboratory and controlled field application tests conducted by Kupetz et al. (1979) indicated the following LD_{50} values for acephate: oral (feeding studies), 1.07 ug/g body weight; topical (direct application), 5.4 ug/g body weight; and contact (with deposit on surfaces), 3,000 ug/100 cm^2 (2.7 lb a.i./acre as deposited).

Additional laboratory studies by Arzone and Vidano (1980) indicated that acephate displayed a high oral toxicity to honey bees at doses 128 times lower than certain suggested crop-spraying application rates, and acephate residues could remain lethal to honey bees upon contact for as long as 52 hours after application.

In Canada, acephate was tested as a possible control for spruce budworm (Buckner and McLeod, 1975). Honey bees were placed in treated and untreated forest plots. Orthene was applied at measured ground level rates ranging from 0.1 to 6.5

lb a.i./acre. In general, honey bees suffered population reduction, and the treatment affected nurse bees within the hives. These adverse effects were recorded for 2 days, and pollen collection was curtailed for up to 5 days. The impact on honey bee colonies was temporary, and seasonal honey production was similar for treated and controlled hives.

Moffett et al. (1979) studied a number of measures to protect apiaries in areas where aerial spray applications of acephate may occur. In general, colonies directly in the path of the spray application suffered greater damage than colonies at the edges of the treated fields. Colonies close to alternate sources of pollen and nectar suffered less than colonies depending on the treated crops. Overall damage could be reduced by applying a combination of preventive management methods before and during spray applications.

Acephate was tested as a candidate control chemical for the Douglas-fir tussock moth as reported by Robinson and Johansen (1978). Part of the test was to determine the effects of acephate on honey bees and other pollinators in the forest environment. Honey bee colonies in the path of aerial spray applications were all dead within 45 and 48 days after treatment, and colonies in untreated plots near the treated areas also were adversely affected. Data from this study indicated that foraging worker bees succumbed to the acephate in the field. Application rates were 1 and 2 lb a.i./acre on selected plots in the Wallowa-Whitman National Forest located in portions of the Blue Mountains and the Wallowa Mountains of northeastern Oregon (Davis et al., 1978).

The results from this study are in contrast to earlier studies on plots in northern Idaho (Johansen, 1975) in which acephate applied at 0.5 lb a.i./acre resulted in relatively low honey bee mortality and residual effects were negligible. This indicates that a number of factors may have been involved that directly affected honey bee intoxication. Some of these factors include application rate, weather conditions, time of day of application. Johansen (1977) classified acephate as a minimal hazard to honey bees if applied during late evening, night, or early mornings on blooming crops, presence and concentration of contaminants in the pesticide formulation (including methamidophos), and proximity of alternative sources of pollen and nectar.

The Douglas-fir tussock moth study (Robinson and Johansen, 1978) also addressed effects on other bees in the same forest plots. Bumble bees and mason bees were the prevalent wild bees, with bumble bees being the major pollinators of forest plants in the study area. Depressions in the numbers of foraging wild bees were apparent in all plots treated with acephate. However, there was no apparent depression of wild

bee populations in the same treated areas in the year following acephate application. The conclusion of the study was that a single application of acephate at an elevation of 4,000 to 6,000 feet is unlikely to cause either a severe or long-term impact because of reductions in insect pollination.

Acephate applied to three experimental plots in a northeastern Oregon forest at 1 and 2 lb a.i./acre had a devastating effect on ants of the genus Formica (Rousch and Akre, 1978). The insecticide was applied during relatively cool weather. As the temperature rose, the foraging activities of the ants increased. Foraging material containing acephate was brought to the colonies, which were effectively dead 6 days after spraying. There was no recovery during the following year.

Toxicity of Methamidophos

Acephate degrades in the environment and is metabolized in animals to methamidophos, a relatively more toxic compound. From 10 to 29 percent of applied acephate may degrade rapidly to methamidophos in the environment depending on the substrate. In albino mice, metabolism of acephate to methamidophos occurred primarily in the gut. About 2.5 percent of the administered dose of acephate was converted to methamidophos in the rat (Lambert, 1985). Studies examining the toxicity of acephate in birds (Junco hyemalis) have also detected residues of methamidophos (Zinkl et al., 1981). EPA has required an avian residue monitoring study because of the high levels of the metabolite methamidophos found in avian foods, including grasshoppers, after a 1 lb a.i./acre application of acephate (U.S. EPA, 1985).

Methamidophos is about 40 to 70 times more toxic than acephate in rats, and 10 times more toxic than acephate in mice (Lambert, 1985). Table A-3 shows the relative toxicities of methamidophos and acephate for various species of mammals.

According to EPA (1982c), methamidophos is very highly toxic to birds and highly toxic to mammals on the basis of a single dose (bobwhite quail LD_{50} = 8 mg/kg; rat LD_{50} = 13 mg/kg). RTECS (1987) lists a rat LD_{50} of 7.5 mg/kg. It is very highly toxic to birds in the diet (bobwhite quail LC_{50} = 42 ppm) but only slightly toxic to mammals in the diet (rat LC_{50} = 894 ppm).

AQUATIC HAZARD

Malathion Toxicity

The acute toxicity of malathion for a number of aquatic organisms is shown in table A-6.

Table A-6--Acute toxicity of malathion to aquatic organisms[1/]

Organism	Water temperature (°C)	Stage or weight (grams)	96-hour LC_{50} (ug/L) (95% confidence interval)
Fish			
Rainbow Trout	12	1.4	200 160-240
Cutthroat Trout	12	1.0	280 270-310
Brown Trout	12	1.1	101 84-115
Lake Trout	12	0.3	76 47-123
Channel Catfish	18	1.5	8,970 6,780-12,000
Black Bullhead	18	1.2	12,900 10,700-15,600
Yellow Perch	18	1.4	263 205-338
Walleye	18	1.8	64 59-70
Largemouth Bass	18	0.9	285 254-320
Bluegill	18	1.5	103 87-122
Green Sunfish	18	1.1	175 134-228
Redear Sunfish	24	3.2	62 58-67
Fathead Minnow	18	0.9	8,650 6,450-11,500
Carp	18	0.6	6,590 4,920-8,820
Goldfish	18	0.9	10,700 8,340-13,800
Invertebrates			
Simocephalus (daphnid)	15	first instar	3.5[2/] 2.6-4.8
Daphnia magna (daphnid)	15	first instar	1.0[2/] 0.7-1.4

Table A-6 (continued)--Acute toxicity of malathion to aquatic organisms[1]

Organism	Water temperature (°C)	Stage or weight (grams)	96-hour LC_{50} (ug/L) (95% confidence interval)
Daphnia pulex (daphnid)	15	first instar	1.8[2] 1.4-2.4
Cypridopsis (seed shrimp)	21	mature	47[2] 32-69
Asellus (sowbug)	21	mature	3,000 1,500-8,500
Gammarus fasciatus (scud)	21	mature	0.76 0.63-0.92
Orconectes (crayfish)	15	early instar	180[3] 140-230
Palaemonetes (grass shrimp)	21	mature	90[3] 67-120
Pteronarcys (stonefly)	15	second year class	10 7.0-13
Pteronarcella (stonefly)	15	naiad	1.1 0.8-1.5
Claassenia (stonefly)	15	second year class	2.8 1.4-4.3
Isoperla (stonefly)	15	first year class	0.69 0.20-2.4
Lestes (damselfly)	15	juvenile	10 6.5-15
Hydropsyche (caddisfly)	15	juvenile	5.0 2.9-8.6
Limnephilus (caddisfly)	15	juvenile	1.3 0.8-2.0
Atherix (snipe fly)	15	juvenile	385 246-602
Amphibians			
Woodhouses' toad (*Bufo woodhousii*)[4]	15.5	--	420

[1]Technical Material, 95 percent.
[2]48-hour EC_{50}.
[3]Tested in hardwater (162-272 ppm C_aCO_3).
[4]Mulla and Mian, 1981.

Sources: Johnson and Finley, 1980; Mulla and Mian, 1981.

Fish

Fish sensitivity to malathion depends on species, water quality, temperature, and exposure times (U.S. EPA, 1975). In general, malathion appears to have a moderate level of toxicity to some species of fish. Species such as carp may tolerate this insecticide at the normal rate of application in mosquito control, whereas others, such as striped bass and mosquito fish, may suffer moderate to high mortality.

Malathion applied for grasshopper control in Montana slightly reduced brain cholinesterase levels between prespray and postspray samples of cutthroat and Eastern brook trout. No effect was observed on the live caged fish as a result of the 8-ounce malathion application (U.S. DOI, 1967). This is the same application rate as that used in APHIS' grasshopper control.

Two farm ponds repeatedly treated with 16 ounces (1.16 lbs) per acre of malathion were studied in a cotton-growing area of Texas. No mortality was reported for resident largemouth bass and other game fish and forage species (Fischer, 1966).

Results from an investigation of the direct effects of a wide-area application of malathion on fish indicated that malathion when aerially applied at the ultra-low-volume rate did not result in direct mortality of captive bluegill (*Lepomis macrochirus*) and fin fish populations native to the stream running through the study area (Dobroski and Lambert, 1984).

An investigation of the relative susceptibility to insecticides of representatives in the families Ictaluridae (catfish), Cyprinidae (minnows), Centrarchidae (sunfish and bass), Percidae (perch), and Salmonidae (salmon, trout, and charrs) demonstrated that members of the families Ictaluridae and Cyprinidae were considerably more tolerant of malathion than species in the other families studied.

Invertebrates

The most acutely sensitive aquatic invertebrates to malathion are scuds (amphipods), stoneflies, and caddisflies (see laboratory test results in table A-6). Field studies support the finding that scuds are sensitive to malathion. Study sites in Wyoming treated with 8 ounces of malathion per acre indicated that the amphipod *Hyalella azteca* (saussure) was reduced to nearly zero and showed no recovery 1 year later (Pfadt et al., 1985).

However, some studies have shown differences between laboratory and field effects on aquatic arthropods. Shrimp and Daphnia have been shown to be very sensitive to malathion in the laboratory, but ground applications at typical mosquito control levels resulted in no significant effects on crustacea, including shrimp and plankton species (Dobroski and Lambert, 1984).

Malathion was not found to be toxic to red crawfish at concentrations that were effective in large-scale control of the target pests (Muncy and Oliver, 1963).

Aerial applications of malathion have been implicated in population reductions of the insect families Chironomidae (midges), Ceratopogonidae (biting midges), Sciaridae (gnats), and Empidae (dance flies) and the orders Collembola (springtails), Plecoptera (stoneflies), and Ephemeroptera (mayflies). However, reductions of aquatic populations appear to be short lived, and rapid recovery is likely (Dobroski and Lambert, 1984).

Aquatic Plants

No adverse effects of malathion on aquatic plants have been reported. Algae metabolize malathion quite rapidly, and the degradation products are not harmful (Mulla and Mian, 1981). Field stuides of ULV aerosol applications of malathion to a salt marsh resulted in no adverse effects to aquatic plants (Tagatz et al., 1974).

Carbaryl Toxicity

The LC_{50}'s of carbaryl for a number of aquatic organisms are shown in table A-7. The toxicity of the technical formulation is greater than the 49-percent oil dispersion formulation (Sevin 4-Oil). The acute aquatic toxicity of carbaryl is relatively low when compared to other insecticides. Members of the catfish (Ictaluridae) and minnow (Cyrinidae) families are nearly 10 times more tolerant of carbaryl than the trout (Salmonidae) family. The toxicity to sunfish and bass (Centrachidae) is approximately midway in this range.

Acetylcholinesterase depressions (13 to 22 percent) have been observed in brook trout within 24 hours of spraying carbaryl at 1 lb/acre. Levels returned to normal within 48 hours. At the same application rate, Atlantic salmon (Salmon salar C.) showed average AChE depression of 20 percent. Levels did not return to normal within 48 hours (Hulbert, 1978; Marancik, 1976).

Some aquatic insects in the orders Plecoptera (stoneflies) and Ephemeroptera (mayflies) are highly sensitive to low levels of carbaryl. Trichoptera (caddisflies) and Diptera (true flies) also are sensitive to carbaryl. There may be a 50- to 100-percent reduction in aquatic insect populations in treated

Table A-7--Acute toxicity of carbaryl to aquatic organisms

Organism	Water temperature (°C)	Stage or weight (grams)	96-hour LC_{50} (ug/L) (95% confidence interval)
Fish			
Rainbow Trout[1/]	12	1.5	1,950 1,450-2,630
Brook Trout[1/]	12	0.8	2,100 1,680-2,620
Brook Trout[2/]	12	1.3	4,500 3,948-5,066
Brook Trout[3/]	--	--	1,100-1,500
Cutthroat Trout[1/]	12	0.5	7,100 5,240-9,620
Cutthroat Trout[3/]	--	--	1,500-2,200
Brown Trout[1/]	12	0.6	6,300 5,520-7,190
Brown Trout[3/]	--	--	2,000
Lake Trout[1/]	12	1.7	690 520-910
Channel Catfish[1/]	18	1.5	15,800 13,900-18,000
Black Bullhead[1/]	18	1.2	20,000 18,000-24,000
Bluegill[1/]	18	1.2	6,760 5,220-8,760
Bluegill[2/]	17	0.7	39,000 29,732-51,157
Green Sunfish	18	1.1	11,200 8,140-15,500
Yellow Perch[1/]	12	0.6	5,100 4,520-5,760
Largemouth Bass[1/]	18	0.9	6,400 4,400-9,200
Black Crappie[1/]	18	1.0	2,600 1,180-5,700
Fathead Minnow	18	0.8	14,600 11,700-19,800

Table A-7 (continued)--Acute toxicity of carbaryl to aquatic organisms

Organism	Water temperature (°C)	Stage or weight (grams)	96-hour LC_{50} (ug/L) (95% confidence interval)
Carp[1/]	18	0.6	5,280 4,620-6,050
Goldfish[1/]	18	0.9	13,200 8,310-20,800
Invertebrates			
Simocephalus[1,4/] (daphnid)	16	first instar	7.6 6.2-9.3
Daphia pulex[1,4/] (daphnid)	16	first instar	6.4 4.5-8.9
Cypridopsis[1,4/] (seed shrimp)	21	mature	115 74-179
Asellus[1/] (sowbug)	18	mature	280 214-367
Gammarus lacustris[1/] (scud)	21	mature	22 16-30
Gammarus fasciatus[1/] (scud)	21	mature	26 16-39
Procambarus[1/] (crayfish)	12	early instar	1,900 1,160-3,110
Palaemonetes[1/] (glass shrimp)	21	mature	5.6 3.6-8.3
Pteronarcella[1/] (stonefly)	16	naiad	1.7 1.4-2.4
Pteronarcys[1/] (stonefly)	16	second year class	4.8 3.0-7.7
Claassenia[1/] (stonefly)	16	second year class	5.6 3.9-8.1
Skwala[1/] (stonefly)	12	naiad	3.6 2.4-5.5
Skwala[2/] (stonefly)	7	first year class	9.2 7.4-12.0

1/Technical Material, 99.5%.
2/Oil dispersion, 49%.
3/U.S. EPA, 1973, as cited in Dobroski, 1985.
4/48-hour EC_{50}.

Sources: Johnson and Finley, 1980; Dobroski, 1985.

streams and ponds (Burdick et al., 1960). Mount and Oehme (1981) found that applications of 1.25 pounds of carbaryl per acre were not directly toxic to fish, but food items were reduced by 97.2 percent. LOTEL (1975) reported that in a stream treated with 1 lb carbaryl/acre, each sampling station recorded a residue of at least 40 ppb and a peak residue of 80 ppb. The biological impact was indicated by increased drift of dead and dying stoneflies, mayflies, caddisflies, and true flies.

The effects of 2 consecutive years of spraying on other aquatic organisms appear similar to those observed in areas treated just once (Trial, 1978, 1979; Courtemanch and Gibbs, 1978). These effects include loss of stonefly species from individual streams and altered generic assemblages for an indefinite period (Trial, 1978, 1979). A study of buffered streams by McCullough and Stanley (1980) during the 1979 Maine spruce budworm spray project indicated that benthic invertebrate fauna were not adversely affected. Also, the numbers of drifting invertebrates were substantially lower than in previous years. The long-term impact appears to be a function of species susceptibility and recolonization ability. Two consecutive years of spraying with carbaryl reduced populations of stonefly and susceptible mayfly genera to near zero.

Carbaryl (Sevin 4-Oil) was applied to woodland ponds in Maine at a rate of approximately 1.85 lb a.i./acre (.84 kg a.i./acre). Caddisfly populations were temporarily reduced. Most severely affected were the amphipods (Hyallela azteca), which were nearly reduced to zero. This group failed to recolonize in some ponds for up to 30 months after spraying (Gibbs et al., 1984).

Diesel and Petroleum Oil Toxicity

The use of Sevin 4-Oil diluted with diesel oil would result in the dispersion of a low dosage of petroleum oils into the environment. Sevin 4-Oil contains nonaromatic, low volatile oils (Union Carbide, 1984) with a flash point of 88 °C (Union Carbide, 1978). The product label of Sevin 4-Oil warns of its high toxicity to aquatic and estuarine invertebrates and prohibits its application over water or wetlands.

Diesel oil contains 25 to 40 percent aromatics and has a flash point of 85 °C (U.S. DOE, 1983). Diesel fuel oil first forms a partial film on surface water, and aromatic compounds can generate materials highly toxic to aquatic organisms (Larson et al., 1977). Oil may be adsorbed on suspended particulates and sink to the bottom, where it may or may not be degraded (Wakeham and Carpenter, 1976). The aromatic components of diesel fuels are toxic to aquatic plants (Baker, 1970), but oil films do not prevent growth of aquatic plants (Roberts, 1930). Perennial freshwater plants seem to be less affected by fuel oil than annual species (Burk, 1977).

Oils may adversely affect fish as a result of toxic constituents, oil coating gill epithelial surfaces, elevated BOD (biochemical oxygen demand), and impacts on food organisms (Morrow, 1974). The 96-hour LC_{50} of No. 2 fuel oil to freshwater fish is 1.20 ppm.

Oils are toxic to mosquito larvae and other aquatic invertebrate species such as crayfish (McKee and Wolf, 1963). The response of phytoplankton species to oil contamination varies significantly (McCauley, 1966).

Aquatic Plants

Carbaryl was nontoxic to a species of fresh-water algae at 1.0 ppm. The growth rate of the algae actually increased after exposure to carbaryl; this was thought to be a result of the increase in available nitrogen (an important plant nutrient) from the degradation of carbaryl (Stadnyk et al., 1971). An increase in algae growth rate after exposure to carbaryl also was reported by Murray and Guthrie (1980).

Concentrations of approximately 10 ppm carbaryl were lethal to three of five species of marine algae. Reproduction was not affected at 1.0 ppm. In one of the five species, growth was inhibited at 0.01 ppm (Ukeles, 1962).

Toxicity of 1-Naphthol

1-Napthol is the major microbial degradation product of carbaryl. In a laboratory study (Stewart et al., 1967), carbaryl was shown to be 30 to 300 times more toxic than 1-naphthol to crustaceans (shrimp and crabs). In the same study, 1-napthol was twice as toxic as carbaryl to fish and mollusks (mussels, clams, and oysters) (Butler et al., 1968; Stewart et al., 1967).

Acephate Toxicity

Fish

Laboratory bioassays indicate that acephate is relatively nontoxic to fish, and lethal dosages are far greater than could be expected from normal grasshopper operational application (Schoettger and Mauck, 1976). The acute LC_{50}'s of acephate for a number of aquatic organisms are shown in table A-8. Tests by Johnson and Finley (1980) indicated that toxicity to trout, bluegill, or yellow perch was not affected by changes in water temperature, pH, or hardness.

Acephate application may change fish feeding habits (Rabeni, 1978). Quantitatively, there was an immediate postspray increase of number of prey and prey volume taken per fish. The number of terrestrial forms (beetles, moths, wasps, and particularly spiders) also increased after spraying and lasted

2 to 3 days before returning to prespray levels. Prey volume per fish remained above prespray levels throughout the study period (8 days).

Rabeni (1978) found that acephate exposure depressed brain acetylcholinesterase activity in white suckers 28 to 29 percent postspray, and AChE activity returned to prespray levels in 8 days. Acetylcholinesterase activity was not depressed in brook trout or Atlantic salmon.

Bluegill sunfish (Lepomis macrochirus Rafinesque), yellow perch (Perca flavescens Mitchill), smallmouth bass (Micropterus dolomieui Lacepede), and bullheads (Ictalurus nebulosus LeSeur) were caged in a pond and observed for 2 weeks before and after an application of 0.5 lb acephate per acre. No mortality or behavioral changes were observed in any of the fish. (LOTEL, 1975).

Amphibians

Amphibians in larval or adult stages were not affected by forest applications of acephate at rates of 0.5 lb and 1 lb a.i./acre (Buckner and McLeod, 1975). The 24-hour LC_{50} for tadpoles of the green frog is 6,433 mg/L (Lyons et al., 1976).

Insects

An acephate application of 0.5 lb a.i./acre resulted in decreased populations of caddisflies (trichoptera) and true flies (diptera); the decreases were temporary and significant only for midges (LOTEL, 1975). A similar application in Maine resulted in decreased populations of caddisflies and mayflies, but reductions were temporary and not detected 9 days after treatment (Rabeni and Gibbs, 1979).

Table A-8--Acute toxicity of acephate to aquatic organisms

Organism	Water temperature (°C)	Stage or weight (grams)	96-hour LC_{50} (mg/L) (95% confidence interval)
Fish			
Rainbow Trout[1]	10	1.5	1,100 775-1,561
Rainbow Trout[2]	10	1.2	730 580-920
Brook Trout[1]	12	0.2	>100
Cutthroat Trout[1]	12	0.7	>100
Cutthroat Trout[2]	12	0.9	>100
Channel Catfish[1]	22	2.0	>1,000
Channel Catfish[2]	22	0.5	560-1,000
Bluegill[1]	20	0.4	>1,000
Bluegill[2]	20	0.4	>1,000
Yellow Perch[1]	12	2.0	>50
Yellow Perch[2]	12	1.8	>100
Largemouth Bass[3]	--	--	1,725
Fathead Minnow[1]	20	1.0	>1,000
Fathead Minnow[2]	20	1.0	>1,000
Invertebrates			
Gammarus pseudolimnaeus[2] (scud)	12	Mature	>50
Pteronarcella[1] (Stonefly)	12	Naiad	9.5 7.3-12.3

Table A-8 (continued)--Acute toxicity of acephate to aquatic organisms

Organism	Water temperature (°C)	Stage or weight (grams)	96-hour LC_{50} (mg/L) (95% confidence interval)
Skwala[1] (Stonefly)	7	Naiad	12 8.7-16
Skwala[2] (Stonefly)	7	Naiad	12 8.0-18
Chironomus[1] (Midge)	20	Fourth instar	>1,000
Amphibians			
Green frog tadpoles (*Rana elamitans*)[4]	--	--	6,433

1/Technical Material, 94%.
2/Soluble Powder, 75%.
3/Orthene 75S. Chevron, 1976, as cited in Lambert 1985.
4/24-hour LC_{50}. Lyons et al., 1976, as cited in Lambert, 1985.

Sources: Johnson and Finley, 1980; Lambert, 1985.

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Appendix B
Details of the Exposure Analysis

This appendix gives the detailed information and calculations used to estimate insecticide exposures to humans, wildlife, and aquatic organisms that could occur in spraying operations for grasshopper control.

The first section discusses the environmental fate properties of each of the insecticides that are relevant to determining their likely fate when they are applied. Because carbaryl is commercially formulated (as Sevin 4-Oil) with petroleum oils and because diesel oil is used as a carrier in the application of Sevin 4-Oil, the environmental fate properties of diesel and petroleum oils are analyzed as well. (Petroleum oil and diesel oil are listed by EPA as inerts of toxicological concern.) Although APHIS does not currently use the Sevin XLR Plus formulation of carbaryl in its control program, it may be used in future years. EPA has indicated that the aqueous formaldehyde used as a preservative in Sevin XLR Plus is an inert of toxicological concern and may be reclassified as an active ingredient (U.S. EPA, 1987). For this reason, the environmental fate properties of this formaldehyde constituent are addressed in this section. Finally, the environmental fate properties of methamidophos, a degradation product of acephate, are addressed.

The second section of this appendix describes the mathematical model used to estimate the transport of each chemical and its fate in various environmental components, particularly its possible movement into bodies of water. The final section presents the assumptions and calculations used to estimate exposures and resultant doses to humans, wildlife, and aquatic organisms. Chapter 4 presents the risk analysis based on these estimated exposures and on the insecticide hazards described in appendix A.

APHIS has extensive guidance regarding the conduct of spraying operations and pilot certification in cooperative treatment programs. This guidance includes the APHIS Grasshopper Cooperative Program Manual, the Aerial Application Manual, and the Operational Procedures listed in table 2-1 in chapter 2. APHIS is committed to complying with all of these procedures. However, to ensure that the calculated exposures are not underestimated (to err on the high side), in many instances the exposure analysis assumes that one or more of these procedures are disregarded.

The risk analysis in this appendix necessarily contains scientific terminology and mathematical formulas. To assist the nontechnical reader, a glossary of technical terms has been included in this EIS as appendix E. The reader also should refer to chapter 4 of the EIS, where the subject matter of this appendix is summarized in less technical terms.

ENVIRONMENTAL FATE OF THE ALTERNATIVE INSECTICIDES

Environmental Fate Properties of Malathion

Chemical and Physical Properties

Malathion is an organophosphate insecticide that exists as a colorless to light amber liquid at standard conditions (25 °C, 1 atmosphere pressure). The preferred chemical name of malathion is 0,0 dimethyl phosphorodithioate of diethyl mercaptosuccinate. (Figure B-1 shows its chemical structure.) Its physical and chemical properties are listed in table B-1 (Dobroski and Lambert, 1984).

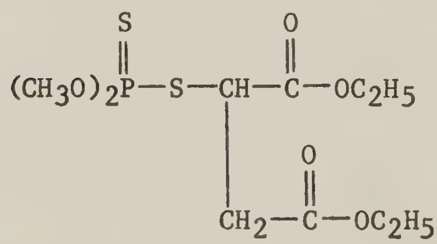

Figure B-1--Structure of malathion

Fate in Soil

EPA (1986a) cites a soil half-life for malathion of 1 day. In alkaline soils with low organic content and low microbial populations, basic hydrolysis may be the primary reaction in the degradation of malathion. Reaction half-lives on the order of 7.5 to 11 days were found in low organic content soils (Gibson and Burns, 1977). Inorganic degradation may be enhanced by the alkaline nature and the lower organic content of these soils in the rangeland (Buckman and Brady, 1969).

Degradation of malathion in higher organic content soils occurs through biologically mediated catalysis by exoenzymes and nonbiological hydrolysis. The breakdown of malathion by exoenzymes occurs from enzyme activity in soil humus and the metabolic activity of microbes. Degradation by enzymes in soil humus is the most rapid process, thus malathion is rapidly consumed in moist soils with significant organic

Table B-1--Properties of malathion

Purity	98.5 - 99.5 percent (analytical grade) 91.95 percent (technical grade)
Boiling point	156 °C (at 0.7 torr)[1/]
Melting point	2.85 °C
Refractive index	1.4985 (25 °C)
Specific Gravity	1.232 (25 °C)
Vapor pressure	1.25 x 10^{-4} mm Hg (20-25 °C)
Octanol-water coefficient	781
Solubility in water	145 ppm (20-25 °C)

[1/] 1 torr = 1/760 of an atmosphere.

content (Gibson and Burns, 1977). A soil half-life of 0.5 days has been reported (Curley and Donohue, 1986). Degradation by direct metabolic activity of soil microbes is important only when the enzyme is not present in soil organic matter (Getzin and Rosefield, 1971). Microbes that metabolize malathion include species of the bacteria Anthrobacter and Tricoderma and the fungi Rhizobium (Matsumura and Baush, 1966; Walker and Stojanovic, 1973).

Malaoxon is a common degradation product of malathion in the soil. It is of concern because its toxicity level is similar to that of malathion. Degradation of malaoxon is primarily by basic hydrolysis (Pascal and Neville, 1976) and half lives of 3.9 to 5 days were found for soils of pH 7.2 to pH 8.2. This indicates that basic hydrolysis will lead to rapid degradation of malaoxon under conditions found in soils of the western States.

Transport of malathion from the soil environment to the atmosphere should be negligible because malathion is a chemical of low volatility (1.25 x 10^{-4} mm Hg at 20 °C). Leaching of malathion from the soil zone also should be minimal because of the low moisture content of the soils during the application period and the low permeability and relatively high sorption capacity of smectitic soils (Borchardt, 1977). An adsorption coefficient (Kd) of 892 mL/g has been reported (Curley and Donohue, 1986). EPA (1986a) cites an adsorption coefficent of 20.0 mL/g.

Fate in Air

Photolysis of malathion and related compounds is too slow to be considered important to the degradation of malathion (Toia et al., 1980). However, the low volatility of malathion

discounts both the likelihood of its presence in air as a vapor and its persistence in the atmosphere. Significant transport of malathion should occur only by drift during application.

Fate in the Aquatic Environment

Degradation of malathion in aquatic environments occurs through basic hydrolysis and microbial activity. Wolfe et al. (1977) found a 36-hour half-life for malathion from basic hydrolysis (pH 8, 27 °C). Degradation products and reaction intermediates include DPTA, diethyl fumarate, monocarboxylic and dicarboxylic acids of malathion, and thiosuccinic acid. Malathion monoacids are also products of hydrolysis and have a half-life of 26 days for inorganic degradation. Biological degradation has been reported to eliminate malathion from river water in 28 days with 75 percent removed in 1 week (Eichelberger and Lichtenberg, 1971). Malathion monoacids have been detected as the primary degradation products from biological reactions. The monoacids persist after malathion has been eliminated (Bourquin, 1977). The degradation products of biological reactions are eliminated only by further degradation reactions (Wolfe et al., 1977). The degradation of malathion may be accelerated by photolysis under ultraviolet radiation. Natural river water with a large amount of organic matter resulted in a half-life for malathion of 15 to 16 hours under sunlight photolysis (Wolfe et al., 1977).

Malathion may be removed from aquatic environments by adsorption to suspended particulates (half-life of 3 days for estuarine sediments (Walker, 1976)). Because of its physical properties, malathion is not removed from aquatic environments by volatilization or precipitation as a solid.

Biological Uptake

The bioaccumulation potential for malathion is low. Its low octanol-water partition coefficient (780) and high solubility (145 mg/L at 28 °C) reflect its low potential for accumulation in lipids (Dobroski and Lambert, 1984). In acidic waters, where malathion is more stable, carp did not bioaccumulate significantly above the level in the water (Bender, 1969). Retention after exposure revealed a half-life of 12 hours in tissue, reflecting relatively rapid elimination of malathion from tissues after cessation of exposure (Kenaga and Goring, 1980).

Fate in Plants

Degradation of malathion on plant surfaces has been reported with half-lives of 15 to 21 hours (Saini and Dobough, 1970) to 5 days (Nigg et al., 1981). Half-lives of ULV applications of malathion at 29.4 °C and 40.5 °C were 21 and 15 hours,

respectively. The half-life of malathion residues on citrus foliage was found to be approximately 5.2 days. Residues of emulsifiable concentrate had half-lives of approximately half the ULV residues. Degradation or disappearance of malathion from plant surfaces showed varying rates. The interval for complete dissipation of malathion (by bioassay) was 5 days on bean plants and 6 days on clover plants. For peaches, the safe interval between malathion treatment and consumption was 1 to 2 days (Dobroski and Lambert, 1984). Trace levels of malathion on plants after 1 week have also been found in other studies (Kashyap and Hameed, 1982).

Malathion has been found to damage a variety of fruit trees and vegetable plants (Thomson, 1979). Affected plants include string beans, apples, Bosc pears, cherries, European grapes, and cucurbits. Some ornamental plants were also found to be affected by malathion. Phytotoxicity of malathion to forested areas was not observed after application at 0.72 lb a.i./acre (Giles, 1970).

Environmental Fate Properties of Carbaryl

Chemical and Physical Properties

Carbaryl is a carbamate pesticide that exists as a white, crystalline powder in pure form and is tan, lavender, or pink in its technical formulation. The chemical name of carbaryl is 1-napthyl (N-methyl-carbamate). (Figure B-2 shows the structure of carbaryl.) Its physical and chemical properties have been summarized in Dobroski (1985). (See table B-2.)

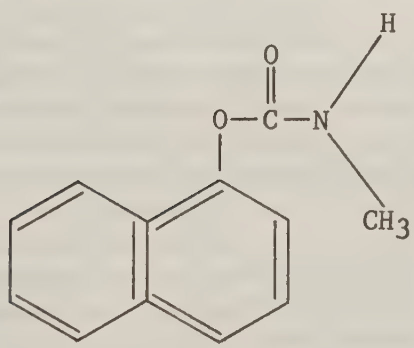

Figure B-2--Structure of carbaryl

Fate in Soil

EPA (1986a) reports a soil half-life of 14 days for carbaryl. Degradation of carbaryl in the soil zone results primarily from the metabolic activity of microorganisms (Heywood, 1975). A half-life in soil of 8 days has been reported by Johnson and Stansbury (1965). Only 6 percent of applied carbaryl could be recovered from treated soil 28 days after application. In

Table B-2--Properties of carbaryl

Purity	80 percent (Sevin Sprayable formulation)
Melting point	142 °C
Specific gravity	1.232 (20 °C)
Vapor pressure	4.1×10^{-5} mm Hg (25 °C)
Solubility in water	40 mg/L (25 °C)
Octanol-water coefficient	230

addition, less than 3 percent remained as water-soluble metabolites. Degradation of carbaryl by soil microorganisms produces several toxic reaction intermediates, including 1-napthol and hydroxy-methylcarbamates. Heywood (1975) also found that 68 percent of hydroxylated metabolites were broken down in soil after 9 weeks. Soils placed in storage were found to degrade a variety of carbamate insecticides at a lower rate. Carbaryl has been found to be degraded by the soil fungus Aspergillus terreus (Liu and Bollag, 1971). Carbaryl degraded with a half-life of 6 days in A. terreus cultures and 1-napthol was also metabolized into unidentified degradation products. Soil mite populations are unaffected by carbaryl (Moulding, 1972). Catalysis of carbaryl degradation by soil minerals is not well understood, but it is clear that the degradation of carbaryl in soils can be attributed more to biological activity than to soil mineral composition (Heywood, 1975).

Field applications of carbaryl were conducted to determine the potential for ground-water contamination (LaFleur, 1976). Soil and ground water samples were taken at monthly intervals. No carbaryl was found in the upper 20 cm of soil after the fourth month (initial application of 50 micromoles per kilogram (umol/kg) soil. Carbaryl desorption values (k_b) of 1.6 to 0.31 were calculated from field data and sorption was correlated to organic content of the soil. EPA (1986a) reports an adsorption coefficent of 2.2 mL/g. Concentrations of carbaryl in ground water peaked at 0.3 umol/L (60 ppb) 2 months after application and dropped to 0.1 umol/L after 4 months. These values represent a maximum for potential migration to ground water because of field conditions (water table depth of 1.1 m and precipitation of 11.4 cm/month). At expected water table depths and precipitation rates in most rangeland application areas, migration of carbaryl to ground water is highly unlikely. Little transport of carbaryl by soil water is expected because of its low solubility (40 ppm) and rapid degradation in soils.

Because of its low volatility (0.005 mm Hg) (Dolinger and Fitch, 1979), transfer of carbaryl from soils to

the atmosphere is too slow to be significant in removing carbaryl from the soil.

Fate in Air

Carbaryl is not expected to be present in air as a vapor because of its low volatility (0.005 mm Hg). Studies of ambient air concentrations of pesticides have not detected carbaryl (Kutz et al., 1976).

Fate in the Aquatic Environment

Carbaryl degrades rapidly in water in 1 to 5 days. Carbaryl applied over open water, such as small brooks or ponds, at an initial deposit of 1 ppm or less in a water depth of about 4 inches may be expected to degrade completely or disappear in 1 or 2 days (Romine and Bussian, 1971; California Department of Fish and Game, 1963; Lichenstein et al., 1966). Results were similar for water treated with Sevin 4-Oil during a gypsy moth suppression project (Willcox, 1972).

The biodegradation rate constant for carbaryl in water is 2.4×10^{-10} mL of substrate/bacterial cell/day (Lyman et al., 1982). The greater the number of bacterial cells in the water, the faster carbaryl will biodegrade. The major metabolite of microbial degradation of carbaryl is 1-naphthol. In a detailed 3-year study of carbaryl in aquatic environments (Felley, 1970), no residues of carbaryl or its major metabolite, 1-naphthol, ever exceeded 0.1 ppm in areas where the pesticide was applied at 1 lb per acre. The ultimate degradation product is carbon dioxide, but investigators in one study suspected that 1-naphthol may be converted to an unidentified, but fairly stable, metabolite that is approximately two-thirds as toxic as 1-naphthol to organisms such as bay mussels (Lamberton and Claeys, 1970).

Carbaryl may be rapidly degraded by hydrolysis at neutral to alkaline pH values (Wolfe et al., 1978; Aly and El-Dib, 1971). These kinetic studies determined half-lives of 1.3 to 1.5 days at a pH of 8 (similar pH values are expected in the rangeland areas of application). Wolfe et al. (1978) found a half-life for photolysis of carbaryl of 6.6 days. Carbaryl was found to be less persistent in natural water at higher pH values (Szeto et al., 1979). This study found biological degradation was significant in the removal of carbaryl; however, these waters existed under conditions that retarded hydrolysis (pH less than 7.5, 9 °C). Only 5 percent of applied carbaryl was recovered from river water after 1 week (Eichelberger and Lichtenberg, 1971).

Under conditions expected in the areas sprayed to control grasshoppers, hydrolysis and photolysis should be primary

pathways for the degradation of carbaryl, and rapid elimination is indicated in studies of laboratory and natural samples.

Biological Uptake

Carbaryl is not subject to significant bioaccumulation in aquatic ecosystems because of its low solubility and low octanol-water partition coefficient (K_{ow} = 230) (Dobroski, 1985). Uptake of carbaryl in fish has been detected, with 95 percent excreted within 8 hours (Tompkins, 1966).

Fate in Plants

The low vapor pressure of carbaryl makes it unlikely that it will volatilize from plant surfaces. The susceptibility of carbaryl to photolysis and its low solubility minimize the possibility of washoff from plants.

Various field studies have been conducted to determine the persistence of carbaryl residues on plants. Residues of Sevin 4-Oil, applied at 0.75 lb a.i./acre in northeastern forests, were found on foliage 60 days after treatment (Ghassemi et al., 1981). A field study of carbaryl residues on foliage, when Sevin 4-Oil was applied at 1 lb a.i./acre, showed the half-life on grass as 8 days, on geraniums as 3 days, on aspens as 8 days, and on Douglas-fir as 4.5 days (Pieper, 1979). This study also reported grass to have the highest percent residue recovered (89.5 percent). In a field study in India, the half-life calculated for cabbage was 3 days and 3.2 days for eggplants (Mann and Chopra, 1969). The calculated half-life of carbaryl, when applied to runoff on apple leaves at 0.5 and 1.0 lb a.i./100 gal, was 13.33 days with a 90-percent reduction in the average surface residue 31 days after treatment (Sell and Maitlen, 1980). When applied to lemon and orange trees at 11.5 lb a.i./acre, residues were reduced by 83 percent and 94 percent, respectively, by 60 days after treatment, and calculated half-lives were 14 days on orange leaves and 22 days on lemon leaves (Iwata et al., 1979). Dissipation rates 8 days after treatment were 81 to 88 percent for spinach and 82 to 85 percent for chicory. Tilden and van Middelem (1970) reported that the rate of dissipation of carbaryl on plants appears to be independent of the initial concentration. The following allowable and actual carbaryl residues were reported for citrus and soybeans: (1) 10 ppm residues were allowable for citrus, and 2 to 8 ppm were found 5 days after treatment (1 lb/100 gal); and (2) 5 ppm residues are allowable for soybeans with 0.96 ppm found 38 days after application (1 to 2 lb a.i./acre) (Clement Associates, 1978). In summary, although dissipation rates of surface residues do not vary according to initial concentrations, the proposed application rate of 0.5 lb/a.i./acre (8 oz a.i./acre) of carbaryl for the grasshopper control program is lower than any of those reported in the

above studies. Therefore, original residues (in ppm) should be lower than those reported.

Small amounts of carbaryl may be absorbed by roots and foliage and distributed into plants (U.S. EPA, 1984). Higher plants have been found to produce some metabolites that remain in the plant tissue and cannot be removed by the usual extraction procedures (Casida and Lykken, 1969; Dorough and Wiggins, 1969). Injection of carbaryl into bean plants led to production of water-soluble compounds that were stable within the plant (Kuhr and Casida, 1967). Studies on bean and cotton plants showed carbaryl to have a 3- to 7-day half-life (Dorough et al., 1963). The plant systems responsible for these changes may be enzymatic or nonenzymatic and may catalyze hydrolysis of the carbamate (Casida, 1963).

Although a portion of the metabolites produced in higher plants is water soluble and may enter the body of animals when the plants are eaten, these soluble metabolites are quickly eliminated (for example, more than 90 percent elimination after 96 hours in rats) by way of the urine and feces (Casida and Lykken, 1969; Dorough and Wiggins, 1969). Of six known higher plant metabolites administered to rats, five were less toxic than carbaryl. The remaining metabolite was more toxic than carbaryl, but it was noted that the metabolite is produced only by a minor metabolic pathway in plants (Wiggins et al., 1970).

Carbaryl is nontoxic to most plants when applied at label rates (Amer, 1965). Carbaryl has been found to injure Boston ivy, Virginia creeper, and maidenhair fern (Union Carbide, 1982), as well as pears, watermelons, and some types of apples (Thomson, 1979). Minor stunting of conifer seedlings also has been observed (Sutherland et al., 1977), and retarded germination of grasses may result from excess dosages of carbaryl (Thomson, 1979). Carbaryl may induce abnormal cell mitosis and meiosis in root tips, but recovery occurs within 48 hours (Amer and Farrah, 1968; Amer, 1965). Seed viability may be increased because of the fungicidal action of carbaryl (Eid et al., 1971).

Environmental Fate Properties of Formaldehyde

Chemical and Physical Properties

Formaldehyde is an organic chemical used as a preservative in pesticide formulations, as a fumigant, and as a fungicide-bactericide. Formaldehyde also has many industrial uses, and it is a naturally-occurring metabolic intermediate. The structure of formaldehyde is shown in figure B-3. The molecular weight of formaldehyde is 30.0. Some of its physical and chemical properties are listed in table B-3. Formaldehyde exists as a gas, but it is usually sold in aqueous solution. Formalin is a name commonly given to formaldehyde solutions,

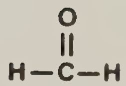

Figure B-3--Structure of formaldehyde

usually ranging from 30 to 56 percent formaldehyde, which usually also contain methanol as an inhibitor of polymerization.

Fate in Soil

The half-life of formaldehyde in soil is 2 to 3 days (BASF, 1987). When released on soil, aqueous solutions containing formaldehyde can leach into the soil (Hazardous Substances Data Bank (HSDB), 1986). Formaldehyde is degraded in soil by bacteria such as Pseudomonas spp. that use formaldehyde as their sole carbon source, and therefore accumulation does not occur (International Agency for Research on Cancer (IARC), 1982). Essentially complete degradation is achieved by soil bacteria in 48 to 72 hours if proper temperature and nutrient conditions exist (Celanese, 1976; Kitchens and Valentine, 1974). Formaldehyde is assimilated into bacterial cellular material through the ribulose monophosphate cycle and the serine pathway. Formaldehyde gas adsorbs somewhat to clay mineral at high concentrations of the gas (De and Chandra, 1978).

Its low octanol/water partition coefficient (log P = 0) (Verschueren, 1983) indicates that soil adsorption will be low (Syracuse Research Center, 1986). Volatilization will not

Table B-3--Properties of formaldehyde

Melting point	-118 °C
Boiling point	-19.5 °C
Vapor Pressure	400 mm at -33 °C
Solubility	miscible with water, acetone, benzene, diethyl ether, chloroform and ethanol
Octanol-water coefficient	0.1348
Reactivity	Very reactive, undergoes self condensation and condenses with numerous compounds.

be high from intact formulation, but as water evaporates so will the formaldehyde. A small amount may remain on soil for a longer time because of interaction with the surface. Such adsorption is expected to be minor. If water percolates, it will carry dissolved formaldehyde. Formaldehyde is biodegradable under both aerobic and anaerobic conditions (Syracuse Research Center, 1986). Reactions of formaldehyde with phenols, urea, or other organics in the environment are possible, but these are not expected to result in significant levels of hazardous compounds (Kitchens et al., 1976).

Fate in Air

Photolysis of formaldehyde is rapid in sunlight, with a measured half-life of 6.0 hours (Su et al., 1979). The input of formaldehyde into the atmosphere is counterbalanced by several important removal paths (National Research Council, 1982), such as photolysis and oxidation (HSDB, 1986). The oxidation of formaldehyde is not expected to lead to any compounds of significant hazard potential (Kitchens et al., 1976). Reaction of formaldehyde with nitrate radicals may be an important removal mechanism at night (National Research Council, 1982). Kitchens et al. (1976) reported that the half-life of formaldehyde in the absence of NO_2 is approximately 50 minutes; in the presence of NO_2 this drops to approximately 35 minutes. Thus, an efficient mechanism exists for the destruction of atmospheric formaldehyde. Because of its high solubility, there is efficient transfer into rain and surface water, which may be an important sink (National Research Council, 1982).

Fate in the Aquatic Environment

When released into water, formaldehyde will biodegrade rapidly to low levels in a few days if the biota in the natural waterways are not overloaded (Kitchens et al., 1976). Biodegradation of formaldehyde in water takes place under both aerobic and anaerobic conditions. In lake water, degradation was complete in 30 hours and 48 hours under aerobic and anaerobic conditions, respectively (Kitchens et al., 1976). In 1966, stagnant lake water was found to contain detectable concentrations of formaldehyde, but only in the hypolimnion (Kitchens et al., 1976). Possible formaldehyde contamination was checked in surface water in 14 heavily industrialized river basins in the United States (214 possible sites). Formaldehyde was detected in only 1 site at 12 ppb. In seawater, formaldehyde was not detected in surface water layers (Kitchens et al., 1976). Formaldehyde has been reported in rainwater in Ireland, Germany, Alaska, and California in concentrations ranging from 6.2 ppb to 1.16 ppm. (Klippel and Warneck, 1978; Zafiriou et al., 1980; Grosjean and Wright, 1983). Little absorption of formaldehyde to sediments in waterways is expected to occur (Syracuse Research Center, 1986). Formaldehyde is a natural

metabolic product and is not subject to bioaccumulation and biomagnification (Kitchens et al., 1976).

Fate in Plants

Kidney bean and barley plants can absorb formaldehyde through their leaves. Maize leaves can form formaldehyde via photosynthesis (Kitchens et al., 1976; Szarvas and Pozsar, 1979). Formaldehyde is present in a variety of vegetables either naturally or as a result of contamination. The residues typically range from 3 to 30 ppm (Tsuchija et al., 1975).

Environmental Fate Properties of Diesel Oil and Petroleum Distillates

Chemical and Physical Properties

Diesel oil and related petroleum distillates are complex mixtures of aliphatic, saturated hydrocarbons that contain smaller amounts of unsaturated, cyclic, and aromatic hydrocarbons. The major components of diesel oil are C_{10}-C_{22} aliphatic compounds. These determine the bulk physical and chemical properties of diesel oil (density 0.82 g/cc, Flash point 85 °C, vapor pressure 2.07 mm Hg (40 °C), boiling range 175 to 470 °C).

Fate in Soil

The fate of diesel oil in the soil environment varies with the physical and chemical properties of its components. The aliphatic, unsaturated hydrocarbons, which comprise the bulk of diesel oil, are insoluble and are preferentially adsorbed to soil minerals and organic matter. Degradation occurs through biological activity of soil microorganisms. Soluble aromatics are mobile and may be leached into ground water (Bonneville Power Administration, 1983).

As the dominant component of diesel oil, the aliphatic hydrocarbons have the properties that determine the fate of most of the diesel oil released into the environment. Octane may be considered representative of this group of compounds. (It is among the smaller molecules found in the aliphatic hydrocarbons, and its properties will give a conservative estimate of the mobility of similar components of diesel oil.) Octane has a low solubility (0.66 ppm at 25 °C) and adsorbs readily to soils (Kd = 110, calculated from Lyman et al., 1981). These properties result in octane being relatively immobile in soils, where it is subject to biodegradation (rate constant = 0.11 day^{-1}) (Ladd, 1956). At an application rate of 0.61 lb/acre, the aliphatic hydrocarbons have little potential for leaching from soils before biodegradation.

Diesel oil also contains small amounts of aromatic hydrocarbons that are water-soluble and of environmental concern because of their toxicity. These compounds include

benzene, toluene, methylbenzenes, and methylnapthalenes. In a preparation of seawater and diesel oil at a ratio of 9:1 (volume:volume), 6.28 ppm of the diesel oil was soluble, mainly as aromatic hydrocarbons (Anderson, 1975). Benzene has a solubility of 1.78×10^3 ppm (at 25 °C). Adsorption of benzene by soils is moderate (Kd = 1.3 calculated from Mabey et al., 1982). These properties indicate that aromatics may be leached into ground water. Based on the solubility data of Anderson (1975), 3.5×10^{-6} lb/acre aromatic hydrocarbons will be applied in the oil used. Potential formification of these constituents is low because of the low levels of initial concentrations. In addition, much of the aromatic compounds may be volatilized during aerial drift, never reaching surface environments (vapor pressure of benzene = 95.2 mm Hg at 25 °C, Mabey et al., 1982).

Fate in Air

Because of the relatively high volatility of diesel fuel (2.07 mm Hg at 90 °C) and its aromatic constituents (95.2 mm Hg at 25 °C for benzene), transfer to the atmospheric environment from drift and surfaces is possible. Because of the low amounts applied (0.61 lb of hydrocarbons/acre), any resulting vapors should dissipate rapidly.

Fate in the Aquatic Environment

Most studies on the fate of petroleum products in aquatic environments have dealt with crude oil spills in marine settings. Application rates would result in 1.8 ppm of diesel oil and petroleum derivatives if directly sprayed on surface waters 1 meter in depth. This concentration exceeds the solubility for the aliphatic hydrocarbons and would result in adsorption to suspended sediment particles (KOC = 5.5×10^3 for octane, calculated from Lyman et al., 1981).

The aromatic hydrocarbons are more soluble than aliphatic compounds (1.78×10^3 ppm for benzene and 535 ppm for toluene, both at 25 °C). Some of the aromatics would be volatilized into the atmosphere before reaching surface waters (Pr = 95.2 mm Hg at 25 °C for benzene). The half-life for volatilization of typical aromatics ranges from 2 to 10 days, based on available values for the Henry's law constants for toluene and benzene (Hc = 6.66×10^{-3} at $mm^3\ mol^{-1}$ for toluene, Hc = 5.5×10^{-3} for benzene, from Mabey et al., 1982).

Bioaccumulation

Many of the constituents of diesel oil and other petroleum distillates have some potential for bioaccumulation. The octanol-water partition coefficients are 1.0×10^4 for octane, 620 for toluene, and 135 for benzene (Mabey et al.,

1982). A bioconcentration factor of 12.6 has been estimated for benzene (Lyman et al., 1981). In exposure studies to marine invertebrates, exposure to a 30 percent solution of the water-soluble fraction (about 2 ppm hydrocarbons) resulted in 10 ppm tissue concentrations in grass shrimp Palaemonetes pugio, with subsequent depuration to 0.2 ppm in 50 hours (Anderson, 1975). In the same study, the clam Rangia cuneata had tissue concentrations of 180 ppm after exposure to 384 ppm oil in oil-water dispersions with depuration to 0.3 ppm after 200 hours. The study revealed that the aquatic invertebrates could expel toxic components of oils from tissues, even after very high exposure levels.

Fate In Plants

Diesel oil is harmful to many plants when applied directly to their surfaces. Diesel oil penetrates the crown of grasses and spreads readily over leaf surfaces. It penetrates many other plants through stomata because oil has a very low surface tension and is not barred from penetration (BPA, 1983; VanOverbeck and Blondeau, 1954). Oil moves into intercellular spaces and in the process may interfere with translocation of metabolic products and nutrients in the plant (Baker, 1970). Oxidation of oils on plant surfaces may lead to toxicity resulting from formation of active peroxides (Larson et al., 1977). These reactions result when diesel oil or other oils are poured or sprayed directly onto plant surfaces. However, the low volumes applied in APHIS' grasshopper control program should not have these detrimental effects on most plant surfaces.

Environmental Fate Properties of Acephate

Chemical and Physical Properties

Acephate is an organophosphate insecticide that is an acetylation product of methamidophos. The chemical name of acephate is O,S-dimethylacetylphosphoramidothioate. (Figure B-4 shows the structure of acephate.) Its physical and chemical properties are listed in table B-4 (Lambert, 1985).

Fate in Soil

A half-life of 7 days has been reported for acephate by EPA (1986a).

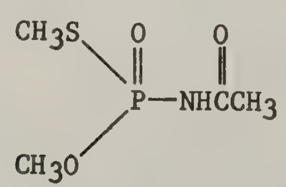

Figure B-4--Structure of acephate

Table B-4--Properties of acephate

Melting point	82-89 °C (technical)
Vapor pressure	2×10^{-6} mm Hg (25 °C)
Solubility in water	65 g/100 mL
Specific gravity	1.046 (2 lb a.i./gal.)
Octanol-water coefficient	0.0428

Microorganisms degrade acephate in the soil. Bacteria have been identified that can use acephate as their sole source of phosphorous (Rosenberg and Alexander, 1979). Some soil fungi also can degrade acephate (Liu and Bollag, 1971). No adverse effects on soil organisms have been attributed to acephate (Focht and Joseph, 1974; Dutcher and Sheppard, 1981).

Nonbiological degradation is not important in the removal of acephate from soil. The biological breakdown rate of acephate depends on the soil type and its moisture content. A half-life of 0.5 to 6 days (at 1.0 ppm of acephate) has been reported (USDA, 1976). During degradation of acephate in soil under a variety of conditions, less than 10 percent of acephate was converted to methamidophos; most was converted directly to innocuous salts.

A soil adsorption coefficient (Kd) of 4.24 has been reported (Curley and Donohue, 1986). EPA (1986a) reported a Kd of 0.1. Because of its high solubility (65 g/100 mL) and low adsorption to soil materials, acephate is susceptible to leaching in the soil zone under some conditions. Acephate was completely leached from soil columns eluted with 4 to 10 inches of water regardless of soil texture (Tucker, 1972c). Studies of aged soils revealed that the remaining acephate (0.02 to 0.05 ppm) could be leached from soil columns; but most acephate had degraded to immobile metabolites, and methamidophos was not detected (Warnock, 1972). Acephate is quite mobile when present. Most acephate breaks down into immobile degradation products before significant transport, even under high rainfall conditions (Chevron, 1973).

Fate in Air

Acephate has low volatility (equilibrium concentration of 2 ppb). Ambient air tests and photolysis experiments, summarized in Lambert (1985), indicate that it is not transferred to the atmosphere from the ground or plant surfaces. Acephate is also relatively resistant to photolysis and does not degrade at a significant rate upon exposure to sunlight.

Fate in the Aquatic Environment

Acephate breaks down relatively slowly in water. The rate of hydrolysis is affected by temperature, pH, and alkalinity. The half-life in water at pH 7 and approximately 70 °F is about 47 days under laboratory conditions (Etter and Tissier, 1973).

Acephate is degraded in water by basic hydrolysis. At a pH of 8.2 and a temperature of 20 °C (68 °F), 78 percent of acephate was recovered from solution after 20 days. At 30 °C (86 °F), only 18 percent was recovered after 20 days (Szeto et al., 1979). Under expected grasshopper control application conditions, basic hydrolysis may be significant in the removal of any acephate that may accidently reach aquatic environments. Szeto et al. (1979) also found that more than 75 percent of applied acephate remained in natural water samples after 45 days; however, the samples were stored at 9 °C (48 °F) so the experiment shows a minimum degradation rate. Also, the presence of bottom sediments in natural waters more than doubled the degradation rates. Field application to surface waters resulted in higher degradation rates. In natural bodies of water, degradation is accelerated by breakdown in aquatic vegetation and microorganisms in sediment. A half-life of 3 to 15 days was reported for ponds in Florida and Iowa treated with 0.1 ppm of acephate (Chevron, 1973). Half-lives ranged between 1 and 3 days in the bottom sediments.

Controlled release of acephate into a flowing creek in British Columbia at 1 ppm was monitored to determine the fate of acephate in natural waters (Hussain and Oloffs, 1980). Acephate concentrations of 1.1 ppm were detected 150 meters downstream during the release of acephate, and levels decreased to 40 ppb within 1 hour of the end of acephate release. At a distance of 2,000 meters downstream, acephate levels peaked at 160 ppb after 8 hours and dropped to 2.7 ppb after 96 hours. No methamidophos was detected in the waters. Acephate and methamidophos dropped to trace levels in sediments after 2 days.

The neutral or alkaline waters typical of the West and the microorganisms present in sediments and vegetation of aquatic environments would be expected to cause relatively rapid degradation rates of acephate.

Bioaccumulation

Acephate has a very low potential for bioaccumulation. The octanol/water partition coefficient is 0.04 (Larson, 1975).

A study in which acephate was injected into a stream showed that fish and insect larvae demonstrated both uptake of acephate and conversion of acephate to methamidophos. Fish uptake of acephate was approximately 1 to 4 percent of the

total acephate in the stream. Approximately 4 to 8 percent of that was converted to methamidophos. By 1 day after injection of acephate, both acephate and methamidophos were cleared from fish tissue. Similarly, insect larvae demonstrated acephate uptake (17 percent of water concentration) and conversion to methamidophos (63 percent of tissue acephate concentration). Tissue levels of acephate and methamidophos were below detection levels 3 hours after termination of acephate release into the stream. The conclusion of the study was that acephate applied in the low ppm level to a natural stream would not be persistent in the water, sediments, or organisms beyond 1 to 4 days, that the levels of acephate and methamidophos encountered would not be bioaccumulated (although they would show uptake in fish and insect larvae), and that acephate would not be acutely toxic to stream organisms (Hussain and Oloffs, 1980; Geen et al., 1981).

Studies using food chain organisms in model ecosystems containing algae, daphnids, emergent plants, insects, and mosquito fish concluded that residues of acephate and its metabolites were not persistent and did not biomagnify along the food chain or accumulate in any ecosystem component. Acephate residues were found only in the model ecosystem water. Metabolic fragments were found incorporated into various tissues, and no acephate residues were detected in fish tissues (Booth, 1975; USDA, 1976).

Bluegill were continuously exposed to 0.01 and 1.0 mg/L acephate for 35 days. A concentration 10 times as high of acephate residues in their tissue occurred as long as exposure occurred. This uptake followed a dose-response relationship in which tissue levels were proportional to environmental levels of acephate in their water. Upon transfer to uncontaminated water, fish exposed to both levels of acephate eliminated more than 50 percent in their edible portions within 3 days. It was concluded that this level of bioaccumulation was minimal and posed no serious threat to the food chain (USDA, 1976).

A study by Hall and Kole (1980) showed that with normal application rates of acephate bioaccumulation by some amphibians may occur that could threaten other nontarget organisms. Another study using tadpoles indicated that acephate did not bioaccumulate to levels that threatened mallard ducklings (Lyons et al., 1976). Tadpoles accumulated acephate in their body tissues but only to concentrations approximately equal to ambient levels. The authors estimated that, at maximum body concentrations anticipated from normal application rates, an adult mallard would have to consume 4,700,000 tadpoles to reach lethal levels. This does not rule out possible sublethal effects, such as changes in cholinesterase activity, but it does indicate a wide margin of safety to certain predators of tadpoles.

Fate in Plants

Residue levels based on chemical analyses were reported as part of a tussock moth control program in Canada (Szeto et al., 1979). For an aerial application rate of 1.12 kg/ha (1.0 lb a.i./acre), decay half-lives in the range of 3 to 6 days were found with no detectable concentrations of acephate or its metabolite methamidophos after 60 days. The vertical distribution of acephate residues was highest in the tree crown area and lowest near the ground. The application rate of this study is considerably higher than the 0.094 lb a.i./acre (1.5 oz a.i./acre) acephate proposed for the grasshopper control program.

The degradation of acephate on plants is thought to follow a common pattern. The fraction of insecticide not absorbed by plant tissue immediately upon application is subject to wash-off, other degradation mechanisms, transport from the plant, and chemical/microbiological breakdown (Robertson and Boeller, 1979). Dislodgeable residues have been found to have a half-life of 24 hours on plant surfaces (Bull, 1978). From the fraction of insecticide absorbed by the plant, 5 to 10 percent is metabolically transformed to methamidophos. Both the remaining acephate and methamidophos are metabolically degraded over time to innocuous salts (USDA, 1976).

Acephate has low or no phytotoxicity for ornamental and tropical plants at proposed application rates. Application is not recommended for American elm, flowering crabapple, sugar maple, cottonwood, or huckleberry (Thomson, 1979). Acephate is toxic to pine seeds and inhibits germination of white spruce and pine seeds but increases germination of yellow birch.

Environmental Fate Properties of Methamidophos

Chemical and Physical Properties

Methamidophos is a transformation product and metabolite of acephate. It is also a manufactured organophosphate insecticide by the trade name of Monitor. The chemical name is O,S-dimethyl phosphoramidothioate. Its chemical structure is shown in figure B-5. Table B-5 lists its chemical and physical properties.

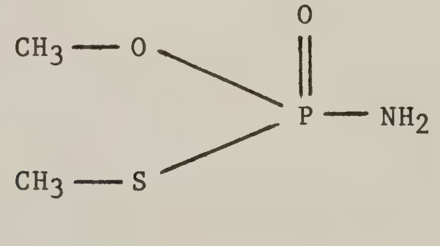

Figure B-5--Structure of Methamidophos

Table B-5--Properties of methamidophos

Melting Point	39-41 °C (for pure compound)
Vapor pressure	1 x 10^{-4} mm Hg (20 °C)
Solubility	Miscible with water and alcohol; < 1% in kerosene; < 10% in benzene or xylene
Specific gravity	1.31 for melted solid

Fate in Soil

Less than 10 percent of acephate residues are present in soil as methamidophos at any one time (Tucker, 1972b). Methamidophos degrades rapidly in soil with a half-life of 6.1 days in sandy soils and 1.9 days in silt (initial concentration 1 ppm) (Leary and Tutass, 1968).

At a higher initial concentration (20 ppm), degradation was still fairly rapid in a sandy loam soil with a half-life of 10 to 12 days at 24 °C (Tucker, 1972a).

Methamidophos is expected to be moderately mobile to very mobile in most types of soils (Dynamac, 1981).

Fate in Air

No information is available on the transformation of acephate to methamidophos in air. See the discussion on acephate for information on fate.

Fate in the Aquatic Environment

Some fraction of acephate may be transformed to methamidophos in aquatic environments; however, no information is available on the rate or extent of this conversion (Lambert, 1985). Methamidophos, like acephate, is degraded by basic hydrolysis and has a similar half-life--44 days and 46.4 days, respectively (pH 7 and 21 °C) (USDA, 1976).

Bioaccumulation

Field studies with 0.5 lb a.i./acre acephate have shown methamidophos residues in grasshoppers of 2.6 to 4.6 ppm (wet weight) at 4 hours after spraying and 0.5 to 0.7 ppm at 53 hours after spraying. These residues were approximately 29 percent and 24 percent, respectively, of the total acephate-methamidophos residues (U.S. EPA, 1986c).

Uptake of acephate by fish is approximately 1 to 4 percent of stream concentrations, with approximately 4 to 8 percent being converted to methamidophos after uptake. Aquatic insect larvae showed higher uptake rates (17 percent) and higher conversion rates (63 percent) (Lambert, 1985).

Studies with mammals have shown transformation of acephate to methamidophos in the gut at levels of 0.6 to 10 percent (U.S. EPA, 1985). Methamidophos is rapidly eliminated in the breath and urine. Goats given 3.75 mg methamidophos daily produced milk with a concentration of 0.003 ppm of parent methamidophos.

Fate in Plants

Methamidophos residues on tomato plants treated with acephate reached a maximum concentration of approximately 7 percent of the initial concentration of acephate at 2 days after spraying (Leidy et al., 1978).

Five to ten percent of the acephate absorbed by a plant is metabolized to methamidophos (USDA, 1976). Similar values were reported by EPA (1985) of up to 10 percent.

The initial half-life of methamidophos residues on tomato plants is 7 to 10 days (U.S. FDA, 1980).

MODELING OF ENVIRONMENTAL TRANSPORT AND FATE

Spray Equipment and Spray Sites

In the grasshopper control program, a wide variety of fixed-wing aircraft are used for insecticide application. The choice of aircraft depends on a variety of factors including the size of the area to be sprayed, volume per acre, topography, ferrying distance, available time, and the availability of aircraft. The APHIS Aerial Application Manual (USDA, 1980) classifies the spray aircraft into five categories with generally similar size, speed, and capacity. The largest aircraft, for example the Douglas DC-4, are in category A. Category B is typified by the PV2 or Martin 404. Category C is typified by the Grumman TBM or the Turbine Thrush. Category D aircraft are usually the smallest used for grasshopper control and include Grumman AgCats and Cessna AgTrucks and AgWagons. A few types of smaller aircraft are classified as category E. (More information on aircraft selection and the capabilities of the aircraft can be found in the APHIS Aerial Application Manual (USDA, 1980).)

The number of acres treated with insecticide each year in the grasshopper control program can be very large, but for the purpose of calculating exposures, it was desirable to identify typical treatment areas that represent spraying occurring on a single day in a single contiguous area. These areas were

chosen to represent an amount that reasonably can be sprayed under favorable conditions. In practice, the area sprayed on a given day (approximately 5 hours of spraying) is often smaller; occasionally it is larger.

It was assumed that typical large sites are treated with four category C aircraft. A single category A aircraft would be able to treat a somewhat smaller area. The areas that can be treated also differ among the three chemicals because the spray volume per acre varies. The total volume of spray used is 8 fluid ounces (fl. oz) per acre for malathion, 20 fl. oz per acre for carbaryl, and 32 fl. oz per acre for acephate. The areas of typical large sites were assumed to be 20,000 acres for malathion, 15,000 acres for carbaryl, and 12,000 acres for acephate.

It was assumed that a typical small site is treated by a single category C aircraft or two category D aircraft. The area of a small site used in this analysis is 4,000 acres for malathion, 2,500 acres for carbaryl, and 2,000 acres for acephate.

The altitude of aircraft during insecticide application is typically 1 to 1.5 times the wingspan of the aircraft. The altitude must sometimes be adjusted for topography because of unevenness or for safety reasons. Aircraft in categories C and D typically fly at 50 to 60 feet above the ground. The nozzles used for application depend on the formulation because of viscosity differences and because of the volume required. The nozzles typically used in the grasshopper control program are 8002-8006 fan nozzles for malathion, 8003-8006 fan nozzles for carbaryl, and 8006-8010 fan nozzles for acephate.

The total pesticide capacity of spray aircraft in category C ranges from about 300 to 600 gallons. The capacity of category D aircraft ranges from about 100 to 400 gallons. The larger aircraft can carry more pesticide, for example, 1,000 to 2,000 gallons for category A aircraft.

For the calculation of exposures in an emergency jettison situation, a realistic load of 200 gallons was used for a category C aircraft.

Spray Drift Modeling

Estimation of spray drift is necessary to calculate exposures downwind of a spray site. The exposures considered in this EIS required estimating residues on the surfaces of people, animals, and plants; in water; and in the air.

Spray drift was estimated based on a model published by Ghassemi et al. (1982). This is not a purely theoretical model; rather it is an empirical model that fitted a lognormal distribution to data from actual measurements taken downwind

of test plots. The data used to fit the model were collected and reported by Yates, Akesson, and Cowden (1978). The data were collected during application of insecticides (carbaryl, acephate, and trichlorfon) to large areas in terrain that varied from steep to gently sloping. The model was applied to six field tests that occurred under meteorological conditions ranging from unstable (lapse) to stable (inversion).

Two of the field tests were selected for the analysis in this EIS: case 1, conducted under neutral to slightly stable conditions in steep terrain, and case 6, conducted under unstable conditions in gently sloping terrain. Cases conducted under inversion conditions were not considered because grasshopper spraying is not done under these conditions. (See operational procedures in table 2-1.)

The model was applied to two types of data: deposition measured on mylar sheets and aerial concentration data collected by filter samplers. The deposition predictions are expressed as a percentage of the application rate, and the aerial concentration data are expressed (based on a 1 lb/acre application rate) as the dose inhaled by a person breathing at 25 liters/minute (typical of moderate activity). Table B-6 shows the predictions for points at 152 m (500 feet) and 10 m (an extrapolation) from the spray site. Both deposition and inhalation doses are much larger for case 1 than case 6. For case 1, the deposition at 10 m is about the same as the onsite application rate, and it declines to 7.5 percent at 152 m. The inhalation dose for people near the spray site (10 m) is only 0.00084 mg, and it declines by a factor of more than 10 at 152 m. The inhalation doses also are given for a breathing rate of 1 liter/minute as a basis for calculating inhalation exposure to wildlife.

Table B-6--Deposition and inhalation doses

Case	Deposition as % of Applied		Mg Inhaled @ 25 L/min		Mg Inhaled @ 1 L/min	
	10 m	152m	10 m	152 m	10 m	152 m
1 (Steep, near neutral)	100	7.5	0.021	0.0018	0.00084	0.000072
6 (gentle slope, unstable)	0.7	0.25	0.0011	0.00023	0.000044	0.0000092

Volatilization of insecticide after treatment is not expected to be a significant source of exposure. However, the formaldehyde used at 0.1 percent as a preservative in Sevin XLR Plus is likely to be somewhat more volatile, reflecting its low molecular weight. The rate of volatilization of formaldehyde from Sevin XLR Plus is not known, but an upper bound can be placed on inhalation exposure by making a few simplifying assumptions. If Sevin XLR Plus is applied at 0.5 lb of active ingredient per acre to a 15,000-acre site and volatilization of formaldehyde is 100 percent complete in a short time into a 5-meter layer of air, then the resulting concentration of formaldehyde would be 0.029 mg/m^3, which is 0.024 ppm. If the wind speed is 2 meters per second, then the air containing the formaldehyde vapor will take about 1 hour to pass. Assuming a breathing rate of 18 liters per minute for a 70-kg person, the total amount of formaldehyde that could be inhaled would be 0.00045 mg/kg of body weight. This total inhaled dose would be approximately the same if vaporization is actually slower but the time of inhalation is correspondingly greater.

Runoff Modeling

Runoff of pesticide from the soil surface was estimated using a modification of the Haith (1980) model. The model was originally validated using pesticide runoff data derived from tests conducted in Georgia. The model considers adsorption and degradation to calculate a mass balance of pesticide in the top centimeter of soil. The pesticide in the surface soil is apportioned to adsorbed and dissolved phases, which are then available for loss as soil and water runoff from the treated plot. Runoff is calculated on a storm-by-storm basis. Runoff of both sediment (erosion) and water are calculated using standard Soil Conservation Service (SCS) techniques.

Erosion was calculated using the Universal Soil Loss Equation (Wischmeier and Smith, 1978). This equation was designed to predict average soil loss in runoff for specific soil, topographic, and vegetation conditions. The equation is based on a large amount of research data and has a long history of use. The basic equation is as follows:

$$A = RKLSCP$$

where:

A = the computed soil loss per unit area

R = the rainfall and runoff factor

K = the soil erodability factor

L = the slope length factor

S = the slope steepness factor

C = the cover and management factor, relating soil loss under specific vegetation and management conditions to continuous fallow

P = the support practice factor, representing the effect of specific practices, for example contouring, that may reduce erosion relative to cultivation up- and down-slope

The Soil Conservation Service has given ample guidance on the selection of numerical values for the various factors in the equation (Wischmeier and Smith, 1978, and a variety of regional publications). Two additions to the equation have been made in the runoff model. First, rainfall erosivity has been calculated on a single-storm basis. Second, provision has been made for the addition of a sediment delivery ratio factor to represent that fraction of sediment leaving a field that reaches a receiving water body. Any buffer area between treated plots and drainage channels, especially a well-vegetated buffer area, will substantially reduce the amount of eroded sediment reaching the channel. Sediment delivery ratios also generally decrease as the size of the drainage area increases (U.S. EPA, 1973). However, to show the maximum possible runoff of soil and any adsorbed pesticide, the examples presented in succeeding paragraphs will assume a sediment delivery ratio of 1.0. This would be realistic only for a treated plot directly adjacent to a stream or other water body. (APHIS requires a 500-foot buffer zone between treatment areas and permanent water bodies.)

The volumes of runoff water were calculated by means of the Soil Conservation Service runoff curve number technique (USDA, 1972). Runoff curve numbers describe the tendency for rainwater to run off the land. The runoff curve number was used in the following equations to predict runoff volumes:

$$S = \frac{1000}{CN} - 10$$

and

$$Q = (P - 0.2S)^2/(P + 0.8S)$$

where:

CN = the runoff curve number

S = a retention parameter

P = the amount of rainfall (inches)

Q = the amount of runoff (inches)

The SCS National Engineering Handbook (USDA, 1972) provides guidance on the choice of runoff curve numbers. The handbook shows runoff curve numbers for various combinations of vegetation cover type and hydrologic soil group. All major soil series have been assigned by SCS to one of the four hydrologic soil groups, A through D. Soils suitable for growing crops are generally in the B or C groups. Soils in group A have an unusually low runoff potential, and soils in group D have an unusually high runoff potential.

The runoff and erosion prediction methods discussed above were combined with the following equations to predict pesticide runoff:

$$P_t = P_o \exp(-\alpha t)$$

$$P_t = A_t + D_t$$

$$A_t = [1/(1 + \theta/(K \times \rho))] \times P_t$$

$$D_t = [1(1 + K \times \rho/\theta)] \times P_t$$

$$PX_t = [X_t/100 \times \rho\ ] \times A_t$$

$$PQ_t = [Q_t/R_t] \times D_t$$

where:

P_t = pesticide concentration at time t (g/ha)

P_o = initial pesticide concentration (g/ha)

α = pesticide degradation constant

t = elapsed time

A_t = adsorbed pesticide (g/ha)

θ = available soil moisture capacity (cm/cm)

K = adsorption coefficient (mg/kg)/(mg/L)

ρ = soil bulk density (g/cm^3)

D_t = dissolved pesticide (g/ha)

PX_t = adsorbed pesticide lost in runoff (g/ha)

X_t = soil loss (tons/ha)

PQ_t = dissolved pesticide lost in runoff (g/ha)

Q_t = runoff (inches)

R_t = rainfall (inches)

Calculations have also been added to the model to estimate the resulting concentrations in a nearby reservoir that catches the runoff or in a small stream draining the treated land. The assumptions used for this scenario are intended to show the highest concentrations that could reasonably be expected to occur in a reservoir. The basic assumptions of the reservoir scenario are the following:

(1) The reservoir is 16 acres in area and 8 feet deep.

(2) The watershed is 500 acres in area.

(3) To account for a 500-foot buffer zone around the reservoir, it is assumed that 90 percent of the watershed is treated with the insecticide.

(4) The treated acreage drains directly into the reservoir or stream, and there is no intervening land or channels that would significantly reduce the insecticide load.

(5) The volume of the reservoir does not change significantly; therefore, the outflow approximately equals the inflow.

(6) Processes within the reservoir, including degradation of the insecticide and sorption to bottom sediments, are not considered. Only the initial concentration has been calculated here.

Example runs are presented in tables B-7 to B-9 for malathion, carbaryl, and acephate, respectively. The runoff curve number used for the simulations was 86, corresponding to rangeland in poor condition on soil from hydrologic group C. This soil group produces moderately high runoff. The rainfall was assumed to be 1.5 inches, falling within the first day after insecticide application. The predicted concentrations are 6 to 7 times higher in the stream than the reservoir because of dilution in the reservoir.

Modeling of Leaching Behavior

A methodology developed for EPA was used to estimate the leaching potential of the insecticides. The Leaching Evaluation of Agricultural Chemicals (LEACH) methodology was developed to assess the potential pesticide leaching from the crop root zone in major agricultural areas of the United States (Dean et al., 1984). The LEACH methodology predicts the frequency of leaching based on 25-year simulations using EPA's Pesticide Root

Table B-7--Runoff model output for malathion

CHEMICAL: Malathion

MODEL PARAMETERS:

PI = 73.09 THETA = .4 KAD = 20 RHO = 1.3 CN = 86
R = 5.326 K = .17 LS = .367 C = .1 P = 1

RESULTS OF SEDIMENT LOSS CALCULATIONS:

KLSCP PER ACRE = 6.239E-03
SOIL LOSS = 8.207E-02 TONS PER HECTARE
AFTER A RAINFALL OF 1.5 INCHES, RUNOFF WAS .4922 INCHES
SEDIMENT CONCENTRATION 595.3 MG PER LITER

PESTICIDE LOSS CALCULATIONS:

RATE = 649.6 KG/HECTARE HALF-LIFE = 1 DAY TIME OF RUNOFF = 1 DAY
FRACTION OF CHEMICAL INTERCEPTED BY VEGETATION = .1
FRACTION OF CHEMICAL IN SOIL OCCURRING IN TOP 1 CM = .25

EDGE-OF-FIELD CONCENTRATIONS:
PX = 2.307E-02 GRAMS PER HECTARE = 609.1 PPB
PQ = 4.136E-03 GRAMS PER HECTARE = 2.902 PPB
TOTAL CHEM CONCENTRATION IN RUNOFF 3.264 PPB

SCENARIO OUTPUTS:

RESERVOIR SCENARIO CALCULATIONS:
RESERVOIR AREA = 16 RESERVOIR DEPTH = 96 IN. SDR = 1
WATERSHED AREA = 500 FRACTION OF WATERSHED THAT IS TREATED = .9
CONC IN RESERVOIR = 0.4349 PPB

STREAM SCENARIO CALCULATION:
CONCENTRATION IN STREAM 2.938 PPB

Table B-8--Runoff model output for carbaryl

CHEMICAL: Carbaryl

MODEL PARAMETERS:

PI = 119.9 THETA = .4 KAD = 2.2 RHO = 1.3 CN = 86
R = 5.326 K = .17 LS = .367 C = .1 P = 1

RESULTS OF SEDIMENT LOSS CALCULATIONS:

KLSCP PER ACRE = 6.239E-03
SOIL LOSS = 8.207E-02 TONS PER HECTARE
AFTER A RAINFALL OF 1.5 INCHES, RUNOFF WAS .4922 INCHES
SEDIMENT CONCENTRATION 595.3 MG PER LITER

PESTICIDE LOSS CALCULATIONS:

RATE = 560 KG/HECTARE HALF-LIFE = 14 DAYS TIME OF RUNOFF = 1 DAY
FRACTION OF CHEMICAL INTERCEPTED BY VEGETATION = .1
FRACTION OF CHEMICAL IN SOIL OCCURRING IN TOP 1 CM = .25

EDGE-OF-FIELD CONCENTRATIONS:
PX = 6.642E-02 2E-026 GRAMS PER HECTARE = 890.2 PPB
PQ = 4.828 GRAMS PER HECTARE = 38.55 PPB
TOTAL CHEM CONCENTRATION IN RUNOFF 39.08 PPB

SCENARIO OUTPUTS:

RESERVOIR SCENARIO CALCULATIONS:
RESERVOIR AREA = 16 RESERVOIR DEPTH = 96 IN. SDR = 1
WATERSHED AREA = 500 FRACTION OF WATERSHED THAT IS TREATED = .9
CONC IN RESERVOIR = 5.207 PPB

STREAM SCENARIO CALCULATION:
CONCENTRATION IN STREAM 35.17 PPB

Table B-9--Runoff model output for acephate

CHEMICAL: Acephate
SOIL TYPE: TIFTON SANDY LOAM

MODEL PARAMETERS:

PI = 21.46 THETA = .4 KAD = 0.1 RHO = 1.3 CN = 86
R = 5.326 K = .17 LS = .367 C = .1 P = 1

RESULTS OF SEDIMENT LOSS CALCULATIONS:

KLSCP PER ACRE = 6.239E-03
SOIL LOSS = 8.207E-02 TONS PER HECTARE
AFTER A RAINFALL OF 1.5 INCHES, RUNOFF WAS .4922 INCHES
SEDIMENT CONCENTRATION 595.3 MG PER LITER

PESTICIDE LOSS CALCULATIONS:

RATE = 105.3 G/HECTARE HALF-LIFE = 7 DAYS TIME OF RUNOFF = 1 DAY
FRACTION OF CHEMICAL INTERCEPTED BY VEGETATION = .1
FRACTION OF CHEMICAL IN SOIL OCCURRING IN TOP 1 CM = .25

EDGE-OF-FIELD CONCENTRATIONS:
PX = 3.322486E-03 GRAMS PER HECTARE = 44.53 PPB
PQ = 5.313166 GRAMS PER HECTARE = 42.42 PPB
TOTAL CHEM CONCENTRATION IN RUNOFF 42.45 PPB

SCENARIO OUTPUTS:

RESERVOIR SCENARIO CALCULATIONS:
RESERVOIR AREA = 16 RESERVOIR DEPTH = 96 IN. SDR = 1
WATERSHED AREA = 500 FRACTION OF WATERSHED THAT IS TREATED = .9
CONC IN RESERVOIR = 5.656 PPB

STREAM SCENARIO CALCULATION:
CONCENTRATION IN STREAM 38.21 PPB

Zone Model (Carsel et al., 1984). The major factors considered include the rate of pesticide degradation in soils (half-life), soil adsorption of the pesticide, climatic factors, and soil characteristics (such as bulk density and water content at field capacity).

The LEACH methodology was applied to the insecticides using wheat and corn growing areas of the Great Plains and Northwestern United States to provide typical site situations (site numbers 1 through 8 in the LEACH handbook).

The following soil adsorption coefficients (Kd's) were used for the insecticides: 20.0 for malathion, 2.2 for carbaryl, and 0.1 for acephate. The half-lives used for degradation in soils were 1 day for malathion, 14 days for carbaryl, and 7 days for acephate (U.S. EPA, 1986a).

A soil bulk density of 1.3 g-soil/cc and a value for soil water content at field capacity of 0.207 cc/cc were used with the Kd values to calculate the retardation factor (R) needed for the leaching analysis. The degradation rate (K's) for each chemical was calculated from the half-life.

The results of the LEACH analysis indicate that malathion and carbaryl do not have significant leaching potential (both of these chemicals were outside the range of values given in the matrices of degradation rates and retardation factors). Acephate has shown potential to leach according to the LEACH analysis. The amount of acephate expected to leach below the rooting zone of wheat crops (8.67 inches or 22 cm) for wheat sites 1 through 5 are, respectively, < 1%, < 2%, < 4%, < 4%, and < 2.3%. These rates are expected to occur only 10 percent of the time.

EXPOSURE CALCULATIONS FOR HUMANS, WILDLIFE, AND AQUATIC ORGANISMS

Human Exposure

This section describes the calculation of human exposures for routine and accident scenarios. The results of the human exposure analysis are presented in chapter 4. The calculated exposures represent a full range of the kinds and magnitude of exposure that could occur, while restricting the calculations to a reasonable number of cases. To avoid underestimating exposures, many parameters and assumptions were chosen so that calculated exposures would err on the high side. The exposure scenarios assume that some required operational procedures are disregarded. Some of the exposures are described as routine, meaning that they could occur under routine circumstances, but only if conditions are conducive to exposure. If operational procedures are complied with, average exposure would

be lower. Exposures have also been calculated for accidental situations that range from those likely to occur occasionally, for example, the direct spraying of a worker, to those that are very unlikely, for example, jettison of a full load of insecticide into a drinking water source. The kinds of exposures calculated for humans are listed in table B-10.

Table B-10--Pathways for human exposures

Workers - Routine

- Pilots (dermal and inhalation)
- Mixer/Loaders (dermal and inhalation)
- Worker at 500 feet (dermal and inhalation)

Workers - Accidental

- Direct spraying
- Spill of concentrate

Public - Routine

- Dermal exposure at 500 feet
- Inhalation exposure at 500 feet
- Oral exposure
  - Grain (directly sprayed)
  - Fish (from water receiving drift)
  - Jackrabbit (from sprayed area)
  - Quail (from sprayed area)
  - Beef (from sprayed area)
  - Water (containing spray drift)

- Total (via dermal, inhalation, grain, water, and highest meat)

Public - Accidental

- Direct spraying of child
- Direct spraying of unregistered crop (leafy vegetable)
- Contaminated drinking water
  - Directly sprayed reservoir
  - Jettison of aircraft load into reservoir
  - Runoff from large thunderstorm into reservoir

Exposures to pilots and mixer/loaders were estimated from a field monitoring study by Atallah et al. (1982). This study has been used to estimate worker exposures by the Exposure Assessment Branch of EPA (Reinert and Severn, 1985). In this study, respiratory exposures were measured with air sampling tubes and a calibrated air sampler attached at the waist. Dermal exposures were measured from hand rinses and denim patches attached to the face, the back of the neck, the front of the neck, the "V" of the upper chest, and the forearms. For this analysis the dermal and respiratory exposures (reported as ug/8-hr work day) in this study were averaged for each of the worker categories and adjusted to an average application rate of 1 lb/acre. Doses to workers were then calculated using the adjusted exposure values and the application rate and dermal penetration rate of each chemical. The typical worker was assumed to wear no special protective clothing and have a body weight of 70 kg (about 150 pounds).

Exposures on sprayed sites and those resulting from accidental direct spraying were based on the full planned application rates in pounds per acre. Exposures 500 feet from the spray site are based on the aerial spray drift model presented previously. It was assumed that the wind blows directly from the spray site, that the terrain is steep, and that the meterological conditions favor drift. Under actual conditions, spray drift should be less than estimated in this analysis. APHIS operational procedures require spraying when winds are less than 10 miles per hour (or less, if required by State law) and under other conditions that minimize drift. (See table 2-1.)

Dermal exposures were estimated for a 70-kg adult wearing short sleeves and trousers, assuming that 2 square feet of skin is covered with insecticide at the full application rate or drift deposition rate. In fact, this procedure is likely to further overestimate exposures because spray droplets, depending on their size and the wind velocity, tend to be carried around obstructions rather than impacting on their surface (see Golovin and Putnam, 1962). Very small droplets, typical of ULV sprays, are the most likely to be carried around obstructions.

Dermal penetration of malathion was estimated to be 7 percent for forearm skin based on a study of human subjects (National Library of Medicine, 1986). Dermal penetration of carbaryl was estimated to be 10 percent based on an analysis of field exposure data (USDA, 1985). Dermal penetration of diesel and petroleum oils was estimated to be 25 percent. Dermal penetration of acephate was estimated to be 10 percent based on a comparison of oral and dermal LD_{50} values (Curley and Donohue, 1986). These penetration estimates were expressed as fixed percentages based on dermal exposure studies that occurred over extended periods of time. In fact, dermal

penetration is time dependent. If a person washes within the first few hours after exposure, then penetration will actually be less than assumed in this analysis. Penetration through clothing was assumed to be 30 percent as great as through bare skin based on work by Newton and Norris (1981) on phenoxy herbicides.

Dermal doses to workers from accidental spills were calculated assuming that one-half liter of insecticide concentrate (or mix for acephate, which is used as a powder) is retained, 90 percent on the worker's clothing and 10 percent on his skin. This amount of liquid is sufficient to wet most of his body.

Dermal doses were calculated for a 20-kg child by varying the surface area according to the 2/3 power of body weight. The child was assumed to have 40 percent of the skin area uncovered.

Inhalation exposure was calculated based on air sampler data collected during field trials, using the model discussed in a previous section. The breathing rate was assumed to be 25 liters per minute, which represents moderate activity for an adult. Inhaled doses were calculated assuming that spray droplets are inspired by people with the same efficiency as by air samplers. One hundred percent of the inspired droplets were assumed to be retained and absorbed.

All oral exposures were calculated assuming that no degradation occurs between spraying and eating or drinking. Label directions require preharvest waiting periods for many crops so that the exposures calculated here apply only if the label is ignored. Residues on crops and range grasses were calculated based on factors given by Hoerger and Kenaga (1972). These factors were derived from a review of a large number of pesticide field studies. The factors reflect differences in surface area, mass, and retention capacity of various plant classes.

Cumulative doses were calculated assuming that degradation occurs according to an exponential curve with half-lives of 5.2 days for malathion, 7 days for carbaryl, and 10 days for acephate. Studies have often shown degradation to be faster than this. The dose was accumulated assuming that 0.5 kg of the leafy vegetable is eaten on each of 5 days beginning on the day of spraying.

Oral doses from eating fish were calculated assuming that the fish is taken from a body of water (pond) 2 feet deep, receiving drift at 500 feet downwind of a sprayed area. The fish was assumed to have residues resulting from equilibration with the water at a bioconcentration factor of 1 for

malathion and carbaryl, 13 for diesel oil, and 10 for acephate. It was assumed that 0.5 kg of the fish is eaten.

Jackrabbit, quail, or beef were assumed to be taken from the sprayed area. Ten percent of the insecticide dose received by the animal, as estimated in the wildlife exposure analysis, was assumed to be retained by the meat. Degradation or excretion was assumed not to occur, and 0.5 kg was assumed to be eaten.

Doses were calculated for humans drinking contaminated water from several accidentally contaminated sources. A shallow (2 feet deep) source was assumed to receive insecticide drift at 7.5 percent of the onsite application rate. No degradation or adsorption to sediments was assumed to occur before drinking 1 liter. The concentrations in the water were calculated as simple dilutions, as listed in U.S. EPA (1986a).

Similarly, exposures were calculated for humans drinking water from a reservoir 16 acres in extent and 8 feet deep that had been directly sprayed. The drinking water exposure also was calculated by dilution for a spill from an aircraft load of 200 gallons into the same size reservoir. Drinking water exposure from a severe thunderstorm was calculated by using the runoff model discussed previously.

The maximum total exposure to an individual was assumed to consist of dermal and inhalation doses plus oral doses from eating a leafy vegetable and the meat above with the highest concentration, and by drinking 1.0 liter of water from a shallow source as described above.

Wildlife Exposure

Representative Species

Wildlife exposures were calculated for a series of representative wildlife species. The results of the wildlife exposure analysis are presented in chapter 4. The species are typical of rangelands across the western States and represent a range of phylogenetic classes, body sizes, and feeding niches. Table B-11 lists the representative wildlife species with various biological parameters used in the exposure analysis. Selection of representative species was done primarily by reference to Lavigne and Pfadt (1966) and Brown (1985). Other references used in the selection and in deriving the physical parameters of each species were Schmidt and Gilbert (1978), Scott et al. (1977), and Burt and Grossenheider (1966).

Exposure Calculations

Exposures were calculated for each representative species for each of the three major exposure routes: inhalation, dermal, and ingestion. Exposures were based on the recommended application rates in pounds of active ingredient per acre.

Table B-11--Biological parameters of representative rangeland wildlife species

Representative species	Body weight (grams)	Body surface area (cm^2)	Vegetation contact (percent)	Percent body groomed	Breathing rate (L/min)
Birds					
Lark Bunting	33	103	77	62	2.05×10^{-2}
Sage Grouse	1,500	1,314	18	21	0.39
Bobwhite Quail	170	307	42	39	7.26×10^{-2}
American Kestrel	125	250	47	42	5.73×10^{-2}
Mammals					
Grasshopper Mouse	32	101	78	63	2.41×10^{-2}
Black-Tailed Jackrabbit	2,722	1,955	15	17	0.84
Pronghorn	46,100	12,903	5	8	8.12
Beef Cow	453,590	59,292	2	4	50.58
Coyote	15,500	6,237	8	10	3.40
Reptiles					
Horned Lizard	25	86	86	0	0.00
Yellow-Bellied Racer	395	539	30	0	0.00
Amphibians					
Rocky Mountain Toad	22	79	90	0	0.01

Inhalation Exposures. Wildlife inhalation exposures were based on air sampling data from field applications of carbaryl and trichlorfon insecticides, adjusted to give a dose at a breathing rate of 1 L/min. The dose was weighted by each animal's breathing rate based on the following equations:

Birds:

$$LPM = \frac{284 \times (BWT/1000)^{.77}}{1000}$$

Mammals:

$$LPM = \frac{379 \times (BWT/1000)^{.80}}{1000}$$

Reptiles:

$$LPM = .00334$$

Amphibians:

$$LPM = .007$$

where:

LPM is the animal's breathing rate in liters per minute

BWT is the animal's body weight in grams

The equations for birds and mammals were taken from Lasiewski and Calder (1971). The reptile value is from Gordon et al. (1968), who report a study on the collared lizard. The breathing rate for amphibians was from Hutchinson et al. (1968).

Dermal Exposures and Doses. Dermal exposures were assumed to come from two sources: (1) directly from insecticide spray, and (2) indirectly by contact with contaminated vegetation. Fur, feathers, and scales afford varying degrees of protection against dermal exposure; by preventing the chemical from reaching the animal's skin, they may instead allow the chemical to dry or to be rubbed off in their movements. For this reason, the dermal penetration value determined in the laboratory for mammals has been adjusted for the three other classes. The dermal penetration factors are as follows: (1) birds, 9.75; (2) reptiles, 0.15; and (3) amphibians, 5.0.

The amphibian factor is high because the moist, glandular skin of the amphibian serves to a large extent as a respiratory organ and is many times more permeable than the other animal classes.

The mammalian dermal penetration rates for the chemicals were assumed to be 7 percent for malathion, 10 percent for carbaryl, 10 percent for acephate, and 25 percent for diesel/petroleum oils.

Wildlife may receive indirect dermal exposure in moving through contaminated vegetation by transferring pesticide from the vegetation to their body surface. The transfer would depend on (1) the density of the vegetation, (2) the animal's body size in relation to the height of the vegetation, and (3) the amount of movement of the animal.

To simplify the analysis, it was assumed that a certain percentage of the animal's total body surface received chemical from contaminated vegetation at the per-acre application rate. That percentage was based on the animal's body size and a movement factor (MVF) to adjust for the taxonomic class. (Mammals, for example, are expected to move more than amphibians.) The animal's total body surface area was assumed to be a function of its weight according to the following formula (Kendeigh, 1970; Schmidt-Nielsen, 1972):

$$BSA = 10 \times (BWT)^{.667}$$

where:

BSA is the animal's body surface area in cm^2

BWT is the animal's body weight in grams

The animal's vegetation contact percent (VCP) is based on its body weight in grams (BWT) according to the following formula:

$$VCP = 2.89\ (BWT)^{-.3775}$$

The class adjustment factors (MVF's) for differing movement are as follows: (1) birds, 0.8; (2) mammals, 1; (3) reptiles, 0.3; and (4) amphibians, 0.4. The indirect dermal dose (IND) is then calculated using the direct dermal dose (DDD):

$$IND = DDD + (DDD \times VCP \times MVF)$$

Mammals and birds groom themselves regularly and may receive an ingestion dose if their fur or feathers are contaminated. The percent of their body surface groomed (PBG) is a decreasing function of their body size according to the following formula:

$$PBG = 1.72\ (BWT)^{-.29}$$

No grooming is assumed for reptiles and amphibians. The oral dose for mammals and birds from grooming is subtracted from the amount of chemical that would contribute to the animal's dermal dose.

Ingestion Doses. Each representative species is assumed to feed on contaminated food items according to a specified diet and to drink a specified amount of water. These dietary amounts are listed in table B-12. The diet items--seeds, grasshoppers, and other insects--are assumed to have the following weights and surface areas:

	weight(g)	surface area (cm^2)	contamination level in ppm based on a 1 lb/acre application
seeds	.002	.158	885
grasshoppers	.25	3.93	176
other insects	.00322	.22	766

These items are assumed to be contaminated over their entire surface area at the direct per-acre application rate. Grass is assumed to be contaminated at the level of 178.9 mg/kg per pound of insecticide applied per acre on site. Water is assumed to be drunk from a stream 1 foot deep that reaches a concentration of 27.6 ppb per pound of insecticide applied per acre. Predators that feed on mice, toads, or quail are assumed to receive the total body burden each of these prey species has received through the three exposure routes described above as a result of the insecticide spraying operation.

Diesel/Petroleum oils on eggs. At the application rate of 0.5 lb a.i./acre for carbaryl, a total of 219.0768 mL of petroleum oil and 118.292 mL of diesel oil are sprayed per acre.

Petroleum oil:

16 fl oz x .463 x 29.573 mL/oz = 219.0768 mL

Diesel oil:

4 fl oz x 29.573 mL/oz = 118.292 mL

The amount of petroleum products combined yield 337.3688 mL applied per acre. This amount is equivalent to 8.3 x 10^{-3} microliters per cm^2. A bird egg with a surface area of 113 cm^2 would receive 0.47 microliters on one-half its surface area.

Table B-12--Representative wildlife species diet items[1/]

Representative Species	Water	Grass	Seeds	Insects	Grasshoppers	Mouse	Toad	Quail
Birds								
Lark Bunting	.02		1	2	6			
Sage Grouse	.10			30	40			
Bobwhite Quail	.05		4	10	20			
American Kestrel	.05				52			
Mammals								
Grasshopper Mouse	.01	1	1	1	6			
Black-Tailed Jackrabbit	.05	300						
Pronghorn	1	2,763						
Beef Cow	58	11,250						
Coyote	.80				40	320		340
Reptiles								
Horned Lizard	.01			3	5			
Yellow Bellied Racer	.01			3	6		22	
Amphibians								
Rocky Mountain Toad	.05			2	2			

1/Water amount in liters; food items in grams.

Methamidophos exposure. Wildlife may be exposed to methamidophos, a toxic breakdown product of acephate, shortly after spraying. The amounts that may occur after spraying are discussed in the environmental fate section of this appendix. A conservation analysis of possible exposure of wildlife to methamidophos used percentages of the amounts of acephate received through the various exposure routes and dietary items as follows:

Methamidophos dermal penetration rate:	10 percent
Amount of acephate converted to methamidophos on skin surface and on the surfaces of grasshoppers and other insects:	29 percent
Amount of acephate converted to methamidophos on plant surfaces and on seeds:	10 percent
Amount of acephate converted to methamidophos in water:	10 percent
Amount of acephate converted to methamidophos in prey animals (mouse, quail, toad) before they are eaten by predators (coyote or snake):	10 percent

The results of the methamidophos exposure analysis and a discussion of the risk from methamidophos under these very conservative assumptions are given in chapter 4.

Aquatic Organisms Exposures

Aquatic organisms are assumed to be exposed to the concentrations of insecticides estimated for water in each scenario. The aquatic organism exposures and representative species are presented in chapter 4. Concentrations in water for the routine scenarios were estimated from modeling the amount of deposition of drift at 500 feet offsite. (See spray drift modeling discussion earlier in this appendix.) The dilution of a pesticide in a stream 1 foot deep and in a pond 4 feet deep was based on EPA (1986b).

Calculations for the direct spraying of a reservoir were based on the amount of onsite deposition of the insecticide at the proposed application rate. (Again, it is assumed that APHIS' 500-foot buffer zone around water bodies is disregarded.) The concentrations were calculated by assuming dilution by the total volume of water in the 16-acre, 8-foot deep reservoir. The concentrations in water from jettisoning a load of 200

gallons also were calculated by using the total volume of water in the reservoir for dilution.

The concentrations in the reservoir resulting from runoff from a heavy thunderstorm were based on the Haith (1980) model. (See the runoff modeling discussions in this appendix.)

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Appendix C
APHIS Pesticide Monitoring and Sampling Procedures

This appendix contains a reproduction of APHIS' plan for environmental monitoring of cooperative programs, sensitive areas, and IPM project areas. It also contains guidelines for environmental monitoring, pesticide sampling procedures, and the research proposal for evaluating the effects of grasshopper IPM projects on migratory birds and other wildlife and fish.

UNITED STATES DEPARTMENT OF AGRICULTURE
ANIMAL AND PLANT HEALTH INSPECTION SERVICE
PLANT PROTECTION AND QUARANTINE

Plan for:

ENVIRONMENTAL MONITORING OF THE RANGELAND GRASSHOPPER COOPERATIVE MANAGEMENT PROGRAM AND GRASSHOPPER INTEGRATED PEST MANAGEMENT PROJECT

Introduction

In order to fulfill the responsibility of the Animal and Plant Health Inspection Service (APHIS) to protect the environment and to assess the environmental impacts of its programs as directed by the National Environmental Policy Act, the Endangered Species Act, and others, a total effort will be expended to prevent, control, and abate adverse effects to the environment.

Contained herein is a broad overview of plans to assess the environmental impact of the Rangeland Grasshopper Cooperative Management Program and Grasshopper Integrated Pest Management (IPM) Project on various nontarget insects, wildlife, and other environmental components. Although this plan should be considered and evaluated on a holistic basis, for logistical and other reasons it will be divided into project areas to be conducted over the next 5 years. These projects are as follows:

1. Programmatic or operational control program environmental monitoring.

2. Special site monitoring for sensitive areas.

1. Programmatic or operational control program environmental monitoring.

2. Special site monitoring for sensitive areas.

3. Grasshopper IPM project monitoring.

Plans to implement these projects are highlighted below and are explained in detail in attached documents.

Individual projects may be adjusted periodically to compensate for new data as it is acquired and analyzed.

I. OPERATIONAL CONTROL PROGRAM MONITORING

Objective: To determine estimated mean residues of program pesticides as determined by gas-liquid chromatograph analysis in water, sediment, vegetation, and target insects at 1 specific posttreatment interval for all grasshopper or Mormon cricket control programs which meet the criteria outlined below.

The primary environmental concerns with grasshopper control programs have been with large scale programs of 20,000 acres and larger. Therefore, in order for a spray block to qualify for environmental monitoring as outlined in this plan, it must be a rangeland protection program and contain a minimum of 20,000 contiguous acres. Cropland protection programs, because of their generally small acreage, will not be routinely monitored. Larger spray blocks may contain more than one monitoring site as follows:

Size of spray block (acres	No. of monitoring sites
Less than 20,000	0
20,000 - 30,000	1
30,000 - 50,000	2
50,000 - 100,000	3
More than 100,000	4-6

Site selection will be left to the discretion of the local APHIS Officer in Charge (OIC), who will consider several factors including, but not limited to, (1) suitability and accessibility of terrain; (2) logistics of sample collection; (3) availability of a water source; (4) location of site in relation to spray block boundaries or sources of contamination; and, (5) representativeness of the site to the area being treated.

Pretreatment samples of water, sediment, and vegetation, will be collected from 1 to 10 days prior to treatment according to procedures described in Attachments A and C. All chemical residues analyses will be conducted by the APHIS National Monitoring and Residue Analysis Laboratory in Gulfport, Mississippi, but samples may be shared with any cooperator upon written request prior to implementation of the program.

II. SPECIAL SITE MONITORING FOR SENSITIVE AREAS

Objective: To develop information to assist in assessing program impact on nontarget organisms.

Certain conditions or criteria will require a more rigorous monitoring effort

to insure that protective measures employed to prevent adverse effects on threatened, endangered and other species of concern are effective: Criteria for implementing special site monitoring plans are as follows:

1. Presence of a peregrine falcon nesting or hack site within or immediately adjacent to the spray block.

2. Presence of threatened or endangered fish within or immediately adjacent to a spray block.

3. Any other condition, when in the opinion of the OIC, after discussions with the U.S. Fish and Wildlife Service (FWS) and others, special site monitoring is determined to be advisable.

4. The first instance of use of Seven-4-Oil, carbaryl bran bait, ULV malathion, or acephate in each State on programs of at least 20,000 acres of totally Federally owned land.

In addition to collecting the environmental components for residues analysis listed under the programmatic monitoring plan (water, silt, vegetation, and target insects), special site monitoring will also include drift monitoring (See Attachment B) and one or more of the following:

A. If birds are the sensitive environmental component:

(1) Bird censusing - utilizing standardized procedures (Burnham, et al, 1981, Line Transect Estimation of Bird Population Density Using Fourier Series, Studies in Avian Biology, No. 6:466-482). The same procedure to be

used by Dr. Lowell McEwen of Colorado State University (CSU); and

(2) Whole body residues in horned larks (a representative species). Birds may be collected by shooting within sample site.

B. If aquatics are the sensitive environmental component:

(1) Population trends of aquatic macroinvertebrates before and after treatment (See Attachment D).

Samples will be collected and censuses taken both within buffer zones surrounding a senstive site as well as within the spray zone which abuts the buffer zone in order to quantify differences which may exist.

Bird censusing and collection are outside the realm of expertise of APHIS/PPQ, the expert assistance of cooperating Federal Agencies (Bureau of Land Management, U.S. Forest Service, Bureau of Indian Affairs) must be requested by the Officer in Charge. If assistance from the above Agencies is not available, assistance from the State cooperators will be sought by the OIC. Should all of the above cooperators be unable to provide the expert assistance necessary, the State office of APHIS, Animal Damage Control should be contacted for expert assistance in censusing and collecting birds.

III. IPM DEMONSTRATION PROJECT MONITORING

Goals and objectives of the Grasshopper IPM Project are detailed elsewhere. Briefly, this project will involve 9 Federal Agencies in a coordinated effort to demonstrate the economic and environmental advantages of utilizing state of

the art IPM technology for grasshopper control. Extensive acreage has been selected for this demonstration at two primary geographic locations (the Boise BLM District, Idaho and McKenzie County, North Dakota or two backup locations Vale, Oregon, and Johnson County, Wyoming). Five treatment options are available for use: any one, or all of these treatments may be chosen based upon a number of factors including grasshopper population densities, climatic conditions, economic factors, etc. These treatment options are as follows:

Chemical	Formulation	Rate/Acre (AI)
acephate	75SP	0.094 lbs
carbaryl	Sevin-4-Oil	0.5 lbs
carbaryl	Wheat bran bait	0.5 lbs
malathion	ULV	.58 lbs
Nosema 1/	Wheat bran bait	
	Grasshoppers	600m to 1.0b spores
	Mormon crickets	1.2b to 2.0b spores

1/ Nosema locustae is a protozoan pathogen

A variety of field research projects will be conducted by Dr. Lowell McEwen, CSU, under cooperative agreement with APHIS. Although the major thrust of this research will be to quantify and compare the effects of all 5 treatment options on bird populations, numerous other environmental components will be studied as well. A noninclusive list of research projects to be implemented are listed below. Research procedures, protocols, budget estimates, etc. for each study are detailed in attached documents.

CSU Environmental Research Projects Objectives - Grasshopper IPM Program

1. Determine the impacts of the control operation on populations of common species of birds within treatment blocks.

2. Determine effects of control applications on mean number of fledglings per area and per nest.

3. Determine the percent of brain inhibition of acetylcholinesterase (ChE) in Kestrels and 2-4 common breeding birds and fish species in the interior of 20,000 acre treatment blocks.

4. Relate mean ChE inhibition of adults to nestling survival and nesting success for Kestrels and 1 to 3 common breeding species.

5. Carry out a pilot study to determine field LD_{50} value with acephate and methamidophos to Kestrels.

6. Determine buffer zone requirements to protect threatened and endangered species and their habitats.

7. Compare sources of exposure of birds and small mammals to the pesticide in bait treatments and liquid sprays.

8. Determine the incidence of lordosis in larval fishes before and after treatment.

9. Determine the effects of the treatments on populations and drifting of aquatic macroinvertebrates before treatment and at intervals following treatment.

10. Determine the mean residue concentrations in field components in the interior of large treatment blocks.

Attachment A

Guidelines for Environmental Monitoring of the Grasshopper or Mormon Cricket Programs

I. Introduction

A grasshopper control program will be conducted in a number of Western States by Plant Protection and Quarantine (PPQ), the States, and the affected landowners. Acreage and locations to be treated will be governed by available monies and grasshopper population assessment survey results and other program factors.

In conformance with the continuing responsibilities of PPQ to assess the environmental impacts of its programs and to fulfill the requirements defined by the National Environmental Policy Act, a monitoring program will be conducted in specified treatment areas. This monitoring program will consist of the sampling of vegetation, target insects, sediment, and flowing and/or impounded water in and/or adjacent to the acreage designated for grasshopper or Mormon cricket control treatment. Field instructions, sample collection supplies, and sample tracking in this monitoring program will be provided as required through Homer Collins, Acting Monitoring Specialist in Gulfport, Mississippi. The National Monitoring and Residue Analysis Laboratory (NMRAL), Gulfport, will provide chemical residue analyses of the environmental samples and will coordinate a final report. The Technology Analysis and Development Staff (TADS), Hyattsville, Maryland, will provide monitoring guidance and perform any needed statistical analyses.

II. Objective

The objective of these guidelines is to provide preliminary data for evaluating environmental effects of the grasshopper control program in terms of chemical residues found in selected environmental components.

III. Treatment Areas and Sampling Sites

The control areas include acreage in several States such as Arizona, Colorado, Idaho, Montana, Nebraska, Oklahoma, Oregon, South Dakota, Texas, Utah, and Wyoming.

A sampling site may include water, sediment, natural occurring vegetation, and target insects. Water for sampling shall be from bodies of water which support higher aquatic life, flowing or impounded (natural or manmade, except stock tanks and pits), with water accessible for sampling. A water site may be within or adjacent to (within 1/4 mile) the treatment area. Sediment samples are to be taken from the same location where the water sample is taken. Vegetation to be sampled shall consist of grass and forbes from within the treatment area. Any moribund wildlife found within the treatment area

following treatment is to be collected for pesticide residue analysis unless death is due to other obvious factors.

IV. Treatments and Application Methods

The grasshopper control treatments will consist of an aerial application of malathion ULV at 0.58 pounds ai per acre, or carbaryl/Sevin 4 Oil at 0.5 pounds ai per acre, or carbaryl bait containing 5 percent carbaryl at 10 pounds of bait (0.5 pounds ai) per acre; or acephate at 0.094 pounds ai per acre.

V. Environmental Components and Sampling

Water samples will be taken at the selected water sites and will consist of a pretreatment sample (10 days or less before treatment) and a posttreatment sample (within 15 to 30 minutes after treatment) at each selected sampling site for a total of two samples per site. Each water sample will have a volume of 1/4 gallon (1 quart). Vegetation samples will consist of a pretreatment sample and posttreatment sample (within 24 hours after treatment). A sample will have weight of 1/2 pound grasses and forbes. Insect samples (grasshoppers) will also be collected (as available) by hand within 24 hours after treatment and will consist of approximately 1/2 pound.

VI. Sample Schedule

Interval		Sample Type	
First (10 days or less before treatment)	sediment*	water*	vegetation*
Second (within 15 minutes following treatment)		water*	
Second (within 24 hours after treatment)	sediment*	vegetation*	insects*

*The total number of sites and samples will depend upon program sites and other considerations available at or prior to the time of treatment.

VII. Monitoring Site Numbers and Maps

Each monitoring site will have a 6-digit number for identification purposes. This number will consist of the two letter abbreviation for the State followed by the numerical order of the site, starting with 0001 in each State. Example: Idaho, First Site + ID0001; Second Site + ID0002; etc.

Field maps are to be prepared which show the sampling site(s) selected for monitoring and the location(s) where samples were taken. These maps (handdrawn will suffice if other types are not available) should be sent with the original sampling for (PPQ 602) and marked for the attention of the Director, NMRAL, P.O. Box 3209, Gulfport, Mississippi 39503.

VIII. Materials and Field Procedures

The various techniques and procedures to be employed in collecting and forwarding the field samples of environmental components are described in

detail in Attachment C, Pesticide Monitoring Sampling Procedures.

Upon request, the field personnel will be provided training by Homer Collins, Acting Monitoring Specialist, in the procedures to be used in the collecting, handling, documenting, and shipping of samples. He may be reached at FTS 499-2622 or commercial Area Code (601) 863-8124.

The material and equipment for sample collection will be supplied by the NMRAL. All samples of environmental components will be forwarded to the NMRAL for chemical analysis.

IX. Scientific Collection Permits

Moribund wildlife may be taken for pesticide residue analyses purposes; Federal permits and State permits will be needed. A Federal permit has been requested for migratory birds. State permits should be sought by the OIC's as necessary.

X. Endangered and Threatened Species

Section 7 of the Endangered Species Act of 1973 states that Federal Agencies shall not authorize, fund, or carry out actions jeopardizing the continued existence of an endangered or threatened species, nor take action which will result in the destruction or adverse modification of its critical habitat. PPQ personnel engaged in sample collecting for monitoring purposes will not be taking any actions that will jeopardize any endangered or threatened species.

XI. Estimated Monitoring Operations Schedule

The intervals for sample taking are covered in the sampling schedule (Sectior VI) and should be adhered to unless unforeseen circumstances arise. Should this occur, the person responsible for the environmental monitoring should contact Homer Collins for further instructions.

XII. Estimated Sample Collection Costs

Current information available is not adequate to estimate the numbers of samples to be collected, therefore, total costs cannot be estimated.

Attachment B

Drift Monitoring Sensitive Area Within the Grasshopper or Mormon Cricket Control Program

I. Introduction

Programs involving large land areas are subject to close review from the general public as well as certain State and Federal regulatory Agencies. This review in several instances is required by State and Federal statutes involving pesticide use and disposal, endangered species, water, or other issues. It is, therefore, imperative that this program maintain proper surveillance throughout.

It is intended that this special monitoring project will evaluate the deposition within buffer zones adjacent to peregrine falcon nesting and hack sites, streams containing endangered aquatic species or other similar sensitive sites identified by the Officer in Charge.

II. Objective

The objectives of this special monitoring project are: (1) To determine if spray enters buffer zones around threatened or endangered speices or their habitat; (2) to determine the presence of any program pesticide in flowing or impounded water (as defined in Attachment A) contained within a sensitive area.

III. Treatment Areas and Monitoring Sites

Treatment areas for the grasshopper or Mormon cricket control program are determined in the field. All monitoring sites for purposes of this plan are associated with identified sensitive sites. Monitoring sites will be placed in and/or adjacent to buffer zones or no aerial treatment zones as identified by this plan. (See Diagrams 1 and 2).

IV. Treatment and Application Methods

Treatments in the grasshopper or Mormon cricket control program may be aerial sprays of malathion ULV at 0.58 pounds active ingredient (ai) per acre, or carbaryl as Sevin-4-Oil, or 5 percent carbaryl bran bait at 0.5 pound ai per acre, or acephate at 0.094 pound ai per acre. For purposes of this plan, only sprays will be monitored.

V. Environmental Components and Sampling

The only environmental component to be collected for this special study will be water when available in sensitive areas in or adjacent to treatment areas. All water samples must be collected, as a pretreatment, and within 15 minutes after the application. The pH of the water sample should be taken and then

immediately buffered to stop degradation. Both carbaryl and malathion rapidly degrade under alkaline conditions.

VI. Sample Schedule

All samples for this plan are to be taken immediately prior to and following an application involving a sensitive site.

Interval	Component
Day of Application	Tank sample of spray mix
Day of Application	Filter papers (placed and removed)
Preapplication Day of application	Water (if available)
Post application (15 to 30 minutes)	Water (if available)

VII. Monitoring the Site, Numbers, and Maps

Each monitoring site shall have a distinctive 6-digit number for identification purposes such as AZ0001 for Arizona; other States use the State abbreviation. Any water collected should be identified with the site number as well. The form to be used for recording sample information is the PPQ Form 602. Each card for drift monitoring shall be identified as to sample site, location in the grid (see Diagram 2), and pesticide used. Site information from drift sites should also be identified as to site number, location, State, county, and sensitive area. Drift studies are to provide wind direction in relation to site, flight path of spray aircraft, temperature, and type of weather.

Maps showing site locations and other information should be submitted with the environmental samples to the National Monitoring and Residue Analysis Laboratory (NMRAL), P.O. Box 3209, Gulfport, Mississippi 39503.

VIII. Materials and Field Procedures

The techniques for handling the environmental samples for this study are detailed in Appendix C "Pesticide Monitoring Sampling Procedure." All sampling and shipping materials will be provided by the NMRAL. Field data relating to environmental samples are to be recorded on PPQ Form 602. The filter papers used in this monitoring plan are to be identified as to site, sequential number and pesticide. All information is to be recorded on PPQ Form 602. The papers should be separated from each other within a site using aluminum foil so as to prevent chemical migration between the papers and to maintain individual site integrity.

IX. Scientific Collection Permits

No collecting permits should be required for this plan.

X. Endangered Species

Endangered species are not directly involved in this plan since the only environmental component to be collected will be water, where available.

XI. Estimated Monitoring Operation Schedule

The dates for collecting samples are dependent on program operations. The PPQ Officer in Charge is instructed to identify sensitive sites for purposes of this plan; therefore, materials and personnel must be available on short notice. Homer Collins, FTS 499-2622 or commercial Area Code (601) 863-8124, will coordinate sample collection for this plan. The NMRAL will provide a report of the analysis as soon as possible after all samples collected in accordance with this plan have been submitted.

XII. Estimated Monitoring Cost

In view of the undetermined nature of this project, a cost estimate is not possible.

Treatment Area

Drift Monitoring Site

500 ft

Buffer Zone

Sensitive Object

Buffer Zone

500 ft

No Treatment Area

Drift Monitoring Site

Treatment Area

Diagram 1. Sensitive Object with Buffer Zone

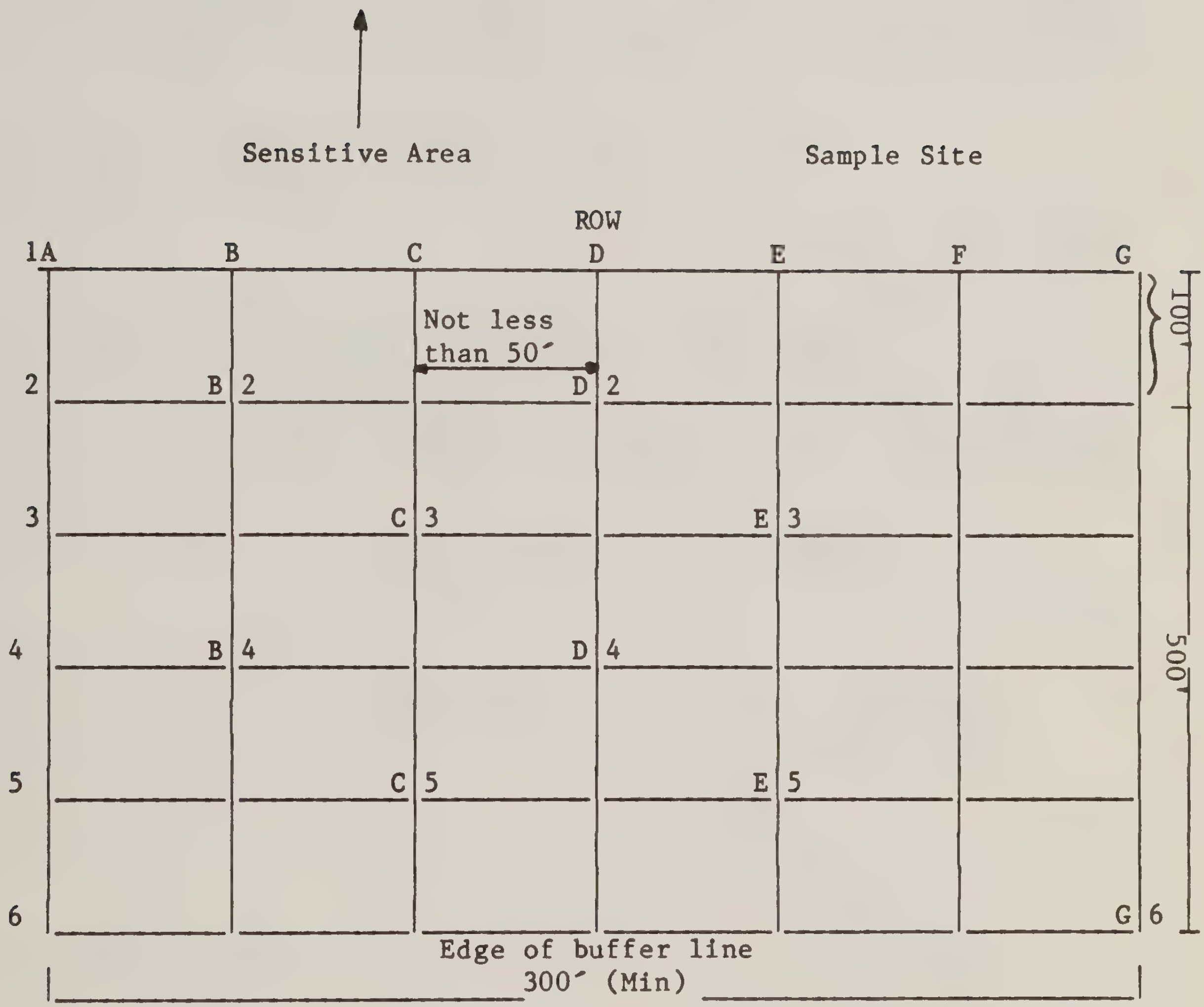

Diagram 2. Drift Monitoring Grid

Enclosure (3) Pesticide Monitoring Sampling Procedures

The position of the National Monitoring Coordinator (NMC) as identified in these documents is no longer funded. Mr. Homer Collins has been assigned as Acting Monitoring Specialist. Any questions regarding sampling equipment, sampling procedure, sample handling, and shipping should be addressed to him. The commercial telephone number is Area Code (601) 863-0862; the FTS number is 499-2622.

M390.1403. Pesticide Monitoring Sampling Procedures

I. GENERAL INFORMATION

This manual part contains the standard procedures for collecting and handling environmental samples for environmental monitoring programs. The specific monitoring plan should be reviewed carefully for the environmental components and for any differences in procedures from those outlined here. Those changes specified in the monitoring plan will take precedence over these guidelines.

A. All samples are to be prepared and shipped in accordance with the instructions of the National Monitoring Coordinator (NMC) and the directions contained in this document. Samples are to be shipped to:

National Monitoring and Residue Analysis Laboratory
USDA-APHIS-PPQ
3505 25th Avenue
Gulfport, MS 39503
c/o Joseph H. Ford

Correspondence is to be mailed to:

National Monitoring and Residue Analysis Laboratory
USDA-APHIS-PPQ
P.O. Box 3209
Gulfport, MS 39503

Telephone numbers:

FTS -- 499-2660
Commercial -- (601) 863-8124

B. The instructions in the detailed procedures to be used in the collection, handling, documentation, and shipment of samples will be handled by the NMC. Guidelines for recording environmental data on PPQ Form 602 are contained in paragraph IV of this manual part. The essential materials and equipment for collecting and shipping samples of environmental components will be provided by the National Monitoring and Residue Analysis Laboratory (NMRAL). The NMC provides the necessary liason between field personnel, NMRAL, and the Technology Analysis and Development Staff (TADS).

The NMRAL should be alerted by telephone when the shipment of perishable material should arrive at the destination, the name of the carrier, the flight number, and other pertinent information.

II. MONITORING PRECAUTIONS

A. Sanitation

1. Clothing -- Gloves, clothing, and shoes that have been exposed to pesticides should not be worn when sampling unless these items have been throughly cleaned with soap and water. Disposable rubber gloves will be provided by the NMRAL for the collecting and screening of samples. Gloves must be changed between each sampling site.

2. Vehicles -- Because of the very nature of this work, pestcide-free vehicles are hard to find. Vehicles that have been used to haul pesticides should be avoided when collecting samples. Before using any vehicle, it must be thoroughly vacuumed and washed inside and out with hot water and soap and rinsed twice. The vehicle should not be used for hauling or storing pesticides during the sampling season. If, for some reason, hauling pesticides becomes absolutely necessary, remove all sampling equipment and thoroughly vacuum and rewash the vehicle before resuming sampling activity. Sampling tools and other equipment should be transported in large heavy gauge cloth bags contained inside a large heavy gauge plastic bag and sealed with masking tape, cord, or comparable sealing material.

3. Tools -- Sampling tools must be thoroughly cleaned immediately before and after sampling each site. Scrub with a brush and water, then rinse with isopropyl alcohol. Use enough so the solvent runs off. Use only the soap or detergent provided by NMRAL. All tools and equipment should be constructed of metal and should be easy to clean. CAUTION -- Use caution in handling all solvents. Use safety goggles when rinsing with solvents. Eye injury can result from spray droplets of isopropyl alcohol, so care should be taken to remain upwind when spray-rinsing equipment. Smoking around solvents must not be allowed as they are extremely flammable.

4. Storage areas -- Sampling equipment and supplies must not be stored to a building used for storing pesticides. A separate, pesticide-free storage area must be used.

All tools and equipment should be plainly labeled as: "MONITORING TOOLS - DO NOT STORE OR TRANSPORT WITH PESTICIDES."

5. Storage and handling of dry ice (carbon dioxide) - -Store in a well ventilated room and assure adequate ventilation when transporting in any vehicle. Handle with gloved hands.

6. Contamination -- Every person collecting samples must be constantly sanitation consious. A little carelessness can result in contamination which can lead to errors in analytical results. Do not enter fields while pesticides are being applied. Return later to collect the sample.

B. Perishable Material: Biological samples (birds, insects, fish, crops, mammals) should be packed in aluminum foil lined bags or heavy duty foil wrap, packaged in dry ice and shipped to the NMRAL immediately

or stored in freezers for shipment at a later date. When wrapping biological samples in foil, wrap shiny side next to sample. The shipping container should be clearly marked on the outside "PERISHABLE--KEEP FROZEN."

C. Labeling: Be sure to label each sample appropriately. Vegetation samples should be labeled so they can be paired with their corresponding soil samples. Label sample containers with State, county, site number, date, and name of contents. For this label, use a soft lead pencil on a strip of masking tape. Be sure to attach the label before leaving the sampling site. A plastic envelope containing the yellow copy of the completed PPQ Form 602 sample data sheet must be securely fastened to the side of the sample container with tape (or between the cloth and plastic bags in the case of the crop samples). Label this envelope with the same information placed on the container itself, (i.e. state, country, site number, date, and name of contents), be sure to place the correct label on each sample. Send completed original PPQ Form 602 (white copy) under separate cover to the NMRAL. The second copy of PPQ Form 602 (pink copy) is to be retained for field records.

It is extremely important that all forms used in conjunction with sampling be completed in detail with a pencil. The information thereon serves as a guide in determining the appropriate analytical procedures and is essential to the analysis of the chemical data. These forms are permanent records. The "Remarks" section should be used for recording any information pertinent to the sample or site that is not elsewhere reported, and particularly anything that is unusual.

D. Regulatory: All samples must be shipped in accordance with quarantine requirements. Samples from regulated areas must be shipped in leak-proof containers. Laboratories receiving samples must handle and dispose of such samples in accordance with regulations.

III. SAMPLING OF ENVIRONMENTAL MEDIA

A. Soil: Soil cores, 50 millimeters (2 inches) in diameter by 75 millimeters (3 inches) deep (unless modified by the monitoring plan) will be taken as specified. Cores should be spaced as uniformly as possible. Do not take soil cores within 2 meters (2 paces) of site borders.

Within the sampling plot, uniformly mark out seven rows of seven soil core points each, and collect a soil core from each soil core point. This configuration will give 49 cores and will supply enough soil for the sample.

If the above procedures are not appropriate for certain sites, make the necessary adjustments. In any event, space cores as uniformly as possible over the site. Do not take cores from fence lines, turn rows or farmsteads. Pass the soil sample through a 6 millimeter (1/4 inch) mesh screen three times to facilitate uniform mixing. Rinse screen with alcohol prior to each use. Force lumps of soil through the screen, but discard stones, roots, twigs, grass, and other debris that will not pass through the screen.

Seal sample container with an airtight lid. NOTE: The lid must be taped on. Label the lid and side of the container with pieces of tape bearing the State, county, and site number, the date, and the sample material (soil in this case).

Complete PPQ Form 602 for each sample, and handle as described under Section II C. Ship samples to the NMRAL as quickly as possible.

Clean equipment thoroughly as described under Section II, A, 3, before reuse and/or storage.

B. Water: The water sources to be sampled are those that may receive runoff from treated areas. Sample the water source within or nearest to the treatment site or as defined in the monitoring guidelines. Sample bottles must be thoroughly cleaned before use. Do not use soap. Rinse thoroughly with clean water, then with isopropyl alcohol and air dry. Seal caps in place with tape after drying. Teflon or aluminum foil may be used as cap liners. A 1.9-2 liter (1/2 gallon) water sample is required.

Take water samples from the bank or edge of the source. Submerge a 2 liter (1/2 gallon) jug below the surface and allow the water to flow in slowly. To collect a sample, gradually move the jug back and forth and up and down in the water with the inlet breaking the surface intermittently and never extended so low as to collect mud from the bottom. Collect water from several places in the source. Care should be taken to avoid disturbing the bottom sediment while collecting the water samples. Complete PPQ Form 602 for each water sample and handle as described under Section II C. Send water samples to the NMRAL at once.

C. Sediment: The sediment should be collected near where the water sample was taken. Use the dredge type, weighted sampler furnished for this purpose. Throw the sampler into the water source and drag it in with a rope. Empty into a clean 11 liter (3 gallon) galvanized pail. The composite sample should consist of at least 10 "grabs" of sediment.

Use a clean stirring tool, such as a large cooking spoon, to mix the sediment thoroughly. If necessary, pass once through a 6 millimeter (1/4 inch) mesh screen to remove leaves, twigs, and other debris. After mixing, allow the sediment to settle out, then pour off excess water. Transfer enough mixed sediment to fill a clean 2 liter (1/2 gallon) sample container and seal the lid. Puncture the lid with a 6d nail and put a small piece of masking tape over the hole.

Complete PPQ Form 602 for each sediment sample and handle as described in Section II C. Forward the sample to the NMRAL at once.

D. Wild Mammals: Most States require a permit to take wild mammals for scientific study. These permits are obtained annually from the appropriate State agencies. A copy of the permit must be carried by persons collecting wild specimens.

Labels will be furnished by the NMRAL for biological samples. The samples should be stored in either an aluminum foil lined bag or wrapped in aluminum foil and placed in a plastic bag. All biological samples should be frozen immediately and shipped in dry ice to the NMRAL as soon as possible. If immediate shipment cannot be made, store biological samples in freezers and ship as soon as possible.

Extreme care should be exercised in handling wild animals. It is suggested that inoculations, such as hepatitis and chick embryo rabies vaccine, be discussed with local medical authorities. Vaccinations are reimbursable.

Local human and domestic animal health and veterinarian regulations should be adhered to when shipping wild animal specimens. All personnel involved in collecting wild animal specimens should be familiar with these regulations. The PPQ Regional Veterinarian is a source of information for these regulations.

A supply of traps will be furnished to field personnel by the NMRAL. Selection of bait is important to the success of this program. In temperate climates, rodents are generally the most abundant mammals. Rodents ranging in size from field rats to field mice and shrews are the specimens of choice. Usually, they will be attracted to peanut butter bait. An acceptable bait mixture is peanut butter with rolled oats. Chunky peanut butter is recommended. Another acceptable bait is a mixture of beef tallow and chicken feed. Also, field tests have shown that pieces of apple serve as good bait for certain field mice.

The small mammals of greatest interest are shrews and cotton mice. It is suggested that sufficient number of traps, not less than ten, be deployed at each site to capture shrews and cotton mice. Other small mammals captured will be acceptable. The manner of trap placement can affect the success of capture. Fallen trees, rocks, other debris, and other forms of cover are attractive to rodents. Place traps in cover and rodent trails rather than in open areas. Traps should remain in place for one 24-hour period only.

Copies of most useful field manuals on identification of mammals in the United States will be furnished to personnel involved in this program. With the aid of these books, identification of most mammals is relatively simple.

Handling and restraint of mammals are important factors in these collecting programs. Mammals may be shaken from traps through the back door into a suitable killing container.

Complete PPQ Form 602 for mammal samples and handle as described in Section II B and C. Ship samples to the NMRAL immediately.

E. Birds: The required Federal and State collection permits are obtained for persons collecting birds in this program. A copy of the permit must be carried by the person collecting the samples. Accurate records must be kept since both State and Federal Agencies require an annual report listing the birds taken and their disposition.

There are several methods of collecting birds. Some of these are Japanese mist nets, cannon traps, and bait traps. The method of choice for this program is the Japanese mist net. Birds may be shot if permission is obtained from proper authorities.

The Japanese mist net is about 12 meters (40 feet) long and 2 meters (6 feet) deep. This net is made of fine black nylon, which is arranged in four shelves or tiers. Different mesh sizes are available depending upon the size of the birds captured. The size designated as #4 bag is the most useful for this program. Mist nets will be furnished to field personnel.

Strategic placement of nets requires some knowledge of bird habits and ecology. Since the capture of many different bird species is desirable, nets must be placed in a variety of habitats. Examples of variety of net placements include net placed in breaks in hedge rows, net placed parallel to edge of wooded or brush areas, net placed parallel to vegetation along water, and net in open field used by birds for active feeding. An area approximately 2 1/2 meters wide and 12 meters (8 feet wide and 40 feet) long should be considered adequate for each net site.

Mist nets will be set up for only one 24-hour period to collect birds. The nets should be opened at daylight and remain in place long enough during the 24-hour period to capture at least ten birds. It may be necessary to set up several nets at a site. Federal regulation requires that mist nets be tended at all times.

The birds of most interest are blackbirds, blue jays, cardinals, catbirds, doves, grackles, meadowlarks, mockingbirds, robins, thrashers, thrushes, and quail. Although the above species are desirable, other species captured should also be forwarded to the NMRAL. Should an endangered species of bird become captured, extreme care should be exercised to prevent harm while releasing it.

Once nets are opened, constant surveillance is required. This is defined as remaining within approximately 5 hectares (12 acres) or one city block of nets and removing captured birds before mortality occurs. Heat from direct sunlight is one of the principle causes of bird deaths in nets. Rain also causes mortality. Predators, such as cats and racoons, will destroy captured birds and also tear nets. Nets should be furled in the evening and in areas containing deer or cattle, the nets should be furled as high as possible. In areas of prevailing winds, adjustments should be made so that nets are placed across the wind to avoid piling up loose net at one end.

Various grains or pieces of bread may be used to bait nets for certain species, such as blackbirds, sparrows, and grackles. Placing three nets in a triangular position with bait in the center is effective.

Sacrifice the bird quickly and prepare for shipping as with mammal specimens. Complete PPQ Form 602 and handle as described in Section II B and C. Copies of the most useful field manuals for bird identification in the United States will be furnished to field personnel involved in this program.

F. Fish: Most States require a permit to take wild fish for scientific study. These permits are obtained, as needed, from the appropriate State agencies.

Although a variety of methods are available for the purpose of collecting fish, a minnow haul seine or fish trap will be used for this program. This equipment will be provided to field personnel by the NMRAL.

Identification of most fish is relatively simple. Some fish, however, are particularly difficult to identify and may require verification by a competent taxonomist.

For this program, it has been determined that a minimum of ten fish should be collected from each sampling site. The fish species most desired are bream and catfish, however, other species that may be captured should be collected. Fish will be collected only during a 24-hour period. Complete PPQ Form 602 for fish samples and handle as described in Section II B and C. Ship samples immediately to the NMRAL.

G. Vegetation: Vegetation samples may consist of grass, plants, leaves, fruit, roots, or tubers from a monitoring site. Plastic bags should not be used for collecting or storing vegetation samples. Either a cloth bag or paper bag lined with aluminum foil should be used for this purpose. These bags may then be placed in a plastic bag for storage and shipment. Plant Material should be packaged in dry ice and should be shipped immediately to the NMRAL. Follow instructions in completing PPQ Form 602 and handle as described in Section II C.

1. Cut handfuls of grass from approximately 50 positions near where each soil core is collected. The mass of the sample should be approximately 225 grams (1/2 pound). If vegetation is sparse, adjust by increasing the area and number of cutting positions. Place grass cuttings in bag as indicated above.

2. Collect fruit samples from around the site tree. Enough fruit should be collected to make a minimum of 225 grams (1/2 pound). Place each type of fruit in a different bag. When individual fruit approximates 225 grams (1/2 pound) (such as large grapefruit), two fruit shall be taken, one each from the opposite sides of the tree. When the fruit are very small and many are required to form a sample (such as cherries), they shall be collected from around the trees.

3. Plant stalks or above-ground plant parts, when required in the monitoring plan, shall be individual stalks sufficient to make a 225 gram (1/2 pound) sample. Long stalks should be cut into 130-250 millimeter (5 to 10 inch) lengths before wrapping for shipment.

4. Leaves collected from site trees in a monitoring program should be taken from around the tree, not from one or two places on the tree. Sufficient leaves should be collected to form a 225 gram (1/2 pound) sample.

5. Roots and tubers from crops in monitoring programs should be taken from around the same site as the soil sample. A sufficient number of roots or tubers should be collected to make a 225 gram (1/2 pound) sample.

6. Small grains, sorghum, soybeans, seed crops, and cottonseed samples to be collected at harvest will be collected with seed covers intact, (i.e., soybean pod, cotton boll, the head of small grain) from the same site as that used to sample the soil. Each type should be bagged seperately. Enough samples should be taken to make a 225 gram (1/2 pound) sample per site.

7. Corn grain to be sampled for residue analysis will be sampled with grain, cob, and husk intact (i.e., the ear, husk, and all). Enough corn ears will be collected to make a 225 gram (1/2 pound) sample of grain when shelled. Shelling will be done at the laboratory. The sample site should be at the same site as for soil sampling.

H. Insects and Spiders: The insects of greatest interest are ground beetles, crickets, and spiders. If other insects are captured, they will be acceptable.

Four pitfall traps, separated by a distance of not less than 7.6 meters (25 feet), will be deployed at each site along the border. An auger or post hole digger should be used to make a hole in the ground the size of a trap. The traps will be placed in the holes so that the tops remain at ground level. The traps will be left in position for a period of 24 hours at a given site.

The insects that fall into the traps will be killed by Dursban crystals. Empty all insects collected onto a sheet of aluminum foil and wrap. Place foil in a zip lock plastic bag. Complete PPQ Form 602 and handle according to Section II C, pack in dry ice, and ship to the NMRAL.

I. Crayfish: Crayfish are the most visible form of fresh water crustaceans and may generally be used to represent this segment of the environment. A minimum of ten crayfish should be collected for each sample.

Some States require a permit to take wild crayfish for scientific study. These permits are obtained from the appropriate State agency. A copy of the permit should be carried by the individual collecting the wild specimens.

Crayfish may be netted, trapped, or seined. Traps for capturing crayfish can be made from 6 millimeter (1/4 inch) hardware cloth and fitted with a reverse funnel at one end and crimped at the other end. The trap may be baited with such materials as fish heads and chicken entrails. A long handled dip net, as used for fish, is useful for catching crayfish as is a lift net. All necessary equipment will be provided by the NMRAL.

Complete PPQ Form 602 for crayfish and handle as described in Section II B and C. Ship samples to the NMRAL immediately.

IV. GUIDELINES FOR RECORDING ENVIRONMENTAL MONITORING DATA ON PPQ FORM 602

A. SITUATION AND OBJECTIVE

In situations where Plant Protection and Quarantine (PPQ) conducts environmental monitoring, samples of specific environmental components are collected for chemical residue analysis at the National Monitoring and Residue Analysis Laboratory (NMRAL), Gulfport, Mississippi. The objective of these Guidelines is to provide an example of how the data which represent the identity of the environmental samples are to be recorded. PPQ Form 602 (October 1981) shall be used for recording all data which are essential to identify the sample and to distinguish it from other samples. This form also provides information for auditing and tracking the sample from field site to laboratory and subsequent transmission of data to the Hyattsville Technology Analysis and Development Staff (TADS). Each field sample submitted for residue analysis must be accompanied by a properly filled-in PPQ Form 602 in order for the sample to be processed. When all field and laboratory work has been completed, the recorded field and analytical data will be verified and keyed into PPQ's computer data file at Hyattsville, Maryland. It is essential, therefore, that PPQ field and laboratory personnel make careful, accurate and legible records of all of the data that are required as described by these Guidelines. Chemical residue data must also be identified explicitly, otherwise, biometrical and mathematical evaluation is prevented.

B. GENERAL

PPQ Form 602 (October 1981) is a 3-part form with a white original and yellow and pink copies. Data that should be recorded by line personnel include 15 fields (groups of boxes) with a total of 65 boxes of specific information. Space for remarks and the name and office telephone number of the sampler is also provided. When the data for a sample have been recorded, the white copy should be mailed in a separate envelope to NMRAL. The yellow copy should be packed and shipped with its sample to NMRAL. The pink copy should be kept on file at the District Office for a three year period. Laboratory data will be recorded in boxes 66 to 117. As many fields as are needed to record all pesticides and residues may be used.

On this form a box is defined as a numbered slot on the form for recording a single character. A field is defined as a group of boxes for recording a specific item of data such as site number. The various fields of PPQ Form 602 are numbered in this revision.

C. INSTRUCTIONS FOR ENTERING DATA

1. Site Number: Boxes 1-6. Site numbers may contain both alphabetic and numeric characters. The written monitoring work plan or guidelines will indicate which site numbers to use. If there is any question, the National Monitoring Coordinator will supply the site numbers. Where site numbers contain less than 6 characters, they should always be right justified. For example, enter the site number 42 as 000042 in boxes 1 through 6. Do not leave blanks. (If all boxes are left blank, those data will be considered missing.)

2. Program: Boxes 7-17. Enter the first 8 characters of the program name (7-14), then from the list below enter the appropriate WBBS code number to represent the program (15-17). Always right justify.

Program Title	Code
Barberry Eradication (BE)	BARBERRY520
Black Grassbug (BG)	BLACKGRA503
Boll Weevil (BW)	BOLLWEEV480
Boll Weevil Eradication (BWE)	BOLLWEEV481
Caribbean fruit Fly	CARIBBEA011
Cereal Leaf Beetle (CLB)	CEREALLE482
Citrus Black Fly (CBF)	CITRUSBL483
Cowpea Striga (CS)	COWPEAST521
Funded Noxious Weed Program (FNW)	FUNDEDNO550
Funded Port Operations	FUNDEDPO552
Golden Nematode (GN)	GOLDENNE511
Grasshopper/Mormon Cricket (GH/MC)	GRASSHOP487
Gypsy Moth (GM)	GYPSYMOT488
Imported Fire Ant (IFA)	IMPORTED489
Japanese Beetle (JB)	JAPANESE490
Khapra Beetle (KB)	KHAPRABE013
Mediterranean Fruit Fly (MEDFF)	MEDITERR505
Mexican Fruit Fly (MEXFF)	MEXICANF484
Miscellaneous General Activities	MISCELLA536
Oriental Fruit Fly	ORIENTAL010
Pest Detection (PD)	PESTDETE550
Pink Bollworm (PBW)	PINKBOLL493
Plant Importation Trust Funds	PLANTIMP983
Range Caterpiller (RC)	RANGECAT494
Reimbursable Noxious Weed	REIMBURS551
Reimbursable Port Operations	REIMBURS554
Scleroderris (SC)	SCLERODE524
Special Studies	SPECIALS001
Sugarcane Smut and/or Rust	SUGARCAN514
Systems Management--Bio Control	SYSTEMSM531
West Indian Sugarcane Root Borer	WESTINDI500
Witchweed (WW)	WITCHWEE522

3. State: Boxes 18 and 19. Enter the two-letter State abbreviation from Table 1. Boxes 20 and 21. Enter the two-digit State location code from Table 1.

4. County: Boxes 22-24. Enter the county location code as listed in GSA Geographic Location Codes Handbook. If the code is unavailable, print the county name in its entirety in the Remarks Section (16).

5. Program Pesticide Code: Boxes 25-28. From Table 2. Enter the appropriate pesticide code. Always right justify. The use of alphabetic characters is premissable for these boxes as indicated.

6. No. of Treatments Applied: Box 29. Enter the number 0 if it is a pretreatment sample. For post-treatment samples, use numerical order of treatments. Example: Use 1 for 1st application, 2 for 2nd application, etc.

7. Environmental Component: Boxes 30 and 31. From the list below, enter the appropriate code to represent the environmental component sampled. When more than one applies, use the most specific. If it is desired to add special purpose codes to this list, please arrange with the National Monitoring Coodinator for a number to use.

Environmental Component	Code	Experimental Component	Code
Agricultural Crops	12	Imported Flowers	15
Air	05	Imported Fruit	14
Birds	07	Imported Vegetables	13
Crustacea	09	Insects	10
Domestic Fruit	20	Mammels	06
Domestic Vegetables	19	Mollusks	11
Experimental Birds	18	Sediment	04
Experimental Fish	17	Soil	01
Experimental Rats	16	Vegetation	02
Fish	08	Water	03

8. Biological or Material Code: Boxes 32-37. If the Environmental component is mammal, bird, or fish, enter the U.S. Department of Interior code from the official code book. For other environmental components, enter the appropriate code from the following table. Use remarks section if more specific identification is available. Always right justify. If it is desired that new codes be added, please check with the Nationl Monitoring Coordinator.

Material	Code	Material	Code
Alfalfa	000027	Grass	000021
Apples	000037	Leaves	000022
Cherries	000039	Nuts	000032
Clam, mussels, etc.	000035	Oranges	000023
Clover	000026	Other citrus	000025
Corn ear w/husk	000029	Other fruit	000042
Corn stalk	000028	Peaches	000038
Crayfish	000034	Plums	000040
Garden vegetables	000033	Small grain heads	000031
Grapefruit	000024	Small grain stems	000030
Grapes	000041	Snails	000036

9. Number of Like Specimens: Boxes 38 and 39. When a sample consists of one item as a bag of corn kernels enter 01. When a sample consists of several like specimens such as 3 blue jays or 2 ears of corn, enter the number of specimens here. Always right justify. Do not combine into one sample different components such as a robin and a blue jay or a cucumber and a squash.

10. Date Sample Collected: Boxes 40-45. Enter the date that the sample was collected using two digits each for month, day, and year.

11. Date of First Application: Boxes 46-49. Enter the date that the 1st treatment was applied using two digits each for the month and day.

12. Date of Second Aplication: Boxes 50-53. If a second application was made at the site, enter the date using two digits each for month and day.

13, 14 & 15. Dates of Third, Fourth, and Fifth Applications. Boxes 54-65. If additional treatments were made at the site, enter the dates in these fields as indicated using two digits each for month and day.

16. Remarks: Enter any additional information the collector may consider appropriate as applies to the sample, site, or treatment. If more than 5 applications are made, indicate the number and dates as remarks.

17. Name of Sample Collector: Enter the name of person taking the sample. Print legibly.

18. Collector's Telephone Number: Enter the collector's office telephone number so if additional information or clarification is needed, the collector may be contacted.

IV. INSTRUCTIONS FOR ENTERING LABORATORY DATA

The remaining fields on PPQ Form 602 are for recording the results of chemical analyses. Data should be entered into these fields only by designated personnel at the NMRAL.

Table 1
State Abbreviations and Location Codes

STATE	ABBREV	CODE	STATE	ABBREV	CODE
Alabama	AL	01	Missouri	MO	29
Alaska	AK	02	Montana	MT	30
Arizona	AZ	04	Nebraska	NE	31
Arkansas	AR	05	Nevada	NV	32
California	CA	06	New Hampshire	NH	33
Colorado	CO	08	New Jersey	NJ	34
Connecticut	CT	09	New Mexico	NM	35
Delaware	DE	10	New York	NY	36
District of Columbia	DC	11	North Carolina	NC	37
Florida	FL	12	North Dakota	ND	38
Georgia	GA	13	Ohio	OH	39
Hawaii	HI	15	Oklahoma	OK	40
Idaho	ID	16	Oregon	OR	41
Illinois	IL	17	Pennsylvania	PA	42
Indiana	IN	18	Rhode Island	RI	44
Iowa	IA	19	South Carolina	SC	45
Kansas	KS	20	South Dakota	SD	46
Kentucky	KY	21	Tennessee	TN	47
Louisiana	LA	22	Texas	TX	48
Maine	ME	23	Utah	UT	49
Maryland	MD	24	Vermont	VT	50
Massachusetts	MA	25	Virginia	VA	51
Michigan	MI	26	Washington	WA	53
Minnesota	MN	27	West Virginia	WV	54
Mississippi	MS	28	Wisconsin	WI	55
			Wyoming	WY	56

Table 2
Program Pesticides and Codes

Acephate (Orthene)	0025
Alachlor (Laso)	4160
Aldicarb (Temik)	0060
Aldrin	0080
Amdro	ADMR
Atrizine	0420
Azinphos-Methyl (Guthion)	3820
Benefin (Balan)	0480
Benomyl	0500
Bensulide (Betasan)	0520
Bromacil	0800
Captan	1020
Carbaryl (Sevin)	1060
Carbofuran (Furadan)	1040
Chlordane	1200
Chlordecone (Kepone)	1280
Chlordimeform (Galecron)	1480
Chlorpyrifos (Dursban)	2900
Cyanazine (Bladex)	1552
D-D	00DD
DDT	1880
Demeton-O (Systox)	1981
Demeton-S (Systox)	1982
Diazinon	2080
Dichloropropene (TeloneII)	2305
Dichlorvos (DDVP)	2320
Dicrotophos (Bidrin)	0700
Dieldrin	2380
Diflubenzuron (Dimilin)	2406
Dimethoate (Cygon)	2420
Dinocap	2560
DSMA	2860
Endosulfan	3180
EPN	3280
Ethion	3340
Ethylene Dibromide	EDBR
(Inorganic Bromide)	INBR
Etridiazol (Turban), (Terrazole)	6590
Unlisted Pesticide	9999
Fensulfothion (Dasanit)	3500
Fenthion (Baytex)	3520
Fenvalerate (Pydrin)	PYDN
Fluchloralin (Basalin)	0407
Fluometuron (Cotoran)	3260
Glyphosate (Round Up)	3901
Heptachlor	3860
Heptachlor Epoxide	3880
Isofenphos (Amaze)	AMAZ
Lindane	0680
Linuron	4240
Malathion	4260
Methamidophos (Monitor)	4750
Methomyl (Lannate)	4520
Methyl Bromide	MEBR
(Inorganic Bromide)	INBR
Methyl Parathion	4580
Mevinphos (Phosdrin)	4640
Mirex	4720
Monocrotophos (Azodrin)	0360
MSMA	4820
Naled (Dibrom)	4860
Norflurazon (Euital)	5136
Oxyfluorfen (Goal)	5230
Paraquat	5240
Parathion	5245
PCNB (Terraclor)	5280
Pendimethalin (Prowl)	5331
Permethrin (Pounce)	PONC
d-Phenothrin	DPHE
Profluralin (Tolban)	5746
Prometryn (Caparol)	5780
Resmethrin	6055
Tepp	TEPP
Toxaphene	6740
Trichlorfon (Dylox)	6780
Trifluralin (Treflan)	6800
2,4-D	2940
2,4,5-T	6840

Guidelines for Environmental Monitoring of the Grasshopper or Mormon Cricket Programs

I. Introduction

A grasshopper and/or Mormon cricket control program may be conducted in a number of Western States by Plant Protection and Quarantine (PPQ), the States, and the affected landowners. Acreage and locations will be governed by available monies, target insect population assessments and survey results and other program factors.

Conforming to its continuing National Environmental Policy Act, responsibilities to assess the impact of its programs on the environment, PPQ will monitor program impacts on aquatic insects. This monitoring program will consist of collecting samples of aquatic insects and water from flowing streams in or adjacent to program treatment areas. Field instructions, sample collection supplies, sample tracking and insect identification (to family) will be provided by Mr. Homer Collins, Acting Monitoring Specialist, in Gulfport, Mississippi. The National Monitoring and Residue Analysis Laboratory (NMRAL), Gulfport will provide chemical residue analysis of the samples collected under this program and will coordinate a final report. The Technology Development Staff will provide monitoring guidance as needed.

II. Objective

The objective of these guidelines is to provide preliminary information for evaluating environmental effects the grasshopper and/or Mormon cricket programs on nontarget aquatic insects in flowing streams.

III. Treatment Areas and Sampling Sites

Control areas may occur in any of several Western States where rangeland grasshoppers and/or Mormon crickets appear in sufficient numbers to require treatment.

This monitoring program may be used in any area where it is desirable to measure aquatic insect populations. Sampling sites will be identified by the Officer in Charge for Sensitive Areas outlined in the Environmental Monitoring of the Rangeland Grasshopper Cooperative Management Program and Grasshopper Integrated Pest Management Project.

IV. Treatments and Application Methods

Program treatments will consist; of aerial applications of malathion ULV at 0.58 pounds ai per acre, or carbaryl/Sevin 4 oil or bran bait at 0.5 pounds ai per acre, or acephate at 0.094 pounds ai per acre.

V. Environmental Components and Sampling

Water and aquatic insects will be collected at selected cites in sensitive program areas. Samples are to be taken at pretreatment (10 days or less before treatment) and at days 1, 5, and 10 posttreatment. Water samples are

to be collected at each interval. In addition the following information is required for each sample--water flow rate, temperature, turbitity, dissolved oxygen content, and pH must be taken and recorded for each sample. The NMRAL will analyze the water for dissolved organic salts and metals and measure conductivity of the raw water. Samples are to be collected in the flowing portion of the stream near or at the stream bottom. Each insect sample is to be collected using a 10-inch diameter, 34 mesh course plankton net, by holding the net for 5 minutes in the flowing portion of a stream.

VI. Sample Interval

Interval	Sample Type	
Pretreatment (10 days or less before treatment)	water	aquatic insects
Posttreatment days 1, 5, and 10	water	aquatic insects

VII. Monitoring Site Numbers and Maps

Each monitoring site will have a 6-digit number for identification purposes. This number will consist of the two letter abbreviation for the State followed by the numerical order of the site, starting with 0001 in each State. Example: Idaho, First Site + ID0001; Second Site + ID0002; etc.

Field maps are to be prepared which show the sampling site(s) selected for monitoring and the location(s) where samples were taken. These maps (handdrawn will suffice if other types are not available) should be sent with the original sampling for (PPQ 602) and marked for the attention of the Director, NMRAL, P.O. Box 3209, Gulfport, Mississippi 39503.

VIII. Materials and Field Procedures

Insect samples collected by this plan are to be identified in accordance with instructions in Attachment C except that insect samples must be identified with their respective water samples on the 602 Form. Numbers for the water and insects must correspond to the site from which they are collected.

Upon request, field personnel will be provided training by Homer Collins, Acting Monitoring Specialist, in the procedures to be used in the collecting, handling, documenting, and shipping of samples. He may be reached at FTS 499-2622 or commercial Area Code (601) 863-8124.

The material and equipment for sample collection and shipping will be supplied by the NMRAL. All samples of environmental components will be forwarded to NMRAL for analysis.

IX. Scientific Collecting Permits

Moribund fish may be collected for purposes of chemical residue analysis; State collection permits should be obtained by Officers in Charge as required.

X. Endangered and Threatened Species

Section 7 of the Endangered Species Act of 1973 states that Federal Agencies shall not authorize, fund, or carry out actions jeopardizing the continued existence of an endangered or threatened species, nor take action which will result in the destruction or adverse modification of its critical habitat. PPQ personnel engaged in sample collecting for monitoring purposes will not be taking any actions that will jeopardize any endangered or threatened species.

XI. Estimated Monitoring Operations Schedule

The intervals for sample taking are covered in the sampling schedule (Section VI) and should be adhered to unless unforeseen circumstances arise. Should this occur, the person responsible for the environmental monitoring should contact Homer Collins for further instructions.

XII. Estimated Sample Collection Costs

Current information available is not adequate to estimate the numbers of samples to be collected, therefore, total costs cannot be estimated.

A PROPOSAL

SUBMITTED TO

UNITED STATES DEPARTMENT OF AGRICULTURE

BY

DEPARTMENT OF FISHERY AND WILDLIFE BIOLOGY
COLORADO STATE UNIVERSITY
FORT COLLINS, COLORADO 80523
(303) 491-6930

TITLE: EFFECTS OF LARGE-SCALE RANGE GRASSHOPPER IPM PROJECTS ON MIGRATORY BIRDS AND OTHER FISH AND WILDLIFE

STATEMENT OF WORK
for
COOPERATIVE AGREEMENT NO. ______________
between
Colorado State University
(hereinafter called the Institution)
and the
United States Department of Agriculture
Animal and Plant Health Inspection Service
(hereinafter called the Service)

1.	TITLE OF PROJECT:	Effects of Large-Scale Range Grasshopper IPM Projects on Migratory Birds and Other Fish and Wildlife
2.	PROJECT LEADERS:	Lowell C. McEwen, Department of Fishery and Wildlife Biology for the Institution, and ______________________, for the Service
3.	LOCATION OF WORK:	Western States
4.	HEADQUARTERS:	[To be determined]
5.	DURATION:	All conditions and provisions of this Cooperative Agreement shall become effective upon date of final signature on Form ____, and shall continue in force until completion of the project, but not later than September 30, 1992. The Service's obligation may be renewed annually until completion of the project, but not later than September 30, 1991. This Cooperative Agreement may be amended at any time by agreement of the parties in writing, or

agreement of the parties in writing, or terminated by either party upon 60 (sixty) days advance notice in writing to the other party.

6. NEED FOR THE PROJECT: Grasshopper epidemics occur on rangelands at economically damaging levels in every western state. The Service (APHIS) has fought this problem by organizing cooperative chemical spray programs averaging about 3 million acres/year. In 1979, the Service sprayed more than 7 million acres and in 1985, the total area exceeded 13 million acres. Application of toxic pesticides on this scale presents a significant hazard to the many species of migratory birds that inhabit sprayed areas and particularly to threatened and endangered species. The planned IPM experiments and demonstration provide a valuable and timely opportunity to provide answers to several long-standing questions about impacts on nontarget wildlife. Such information is badly needed to integrate the management of migratory bird species with forage protection and grasshopper control on rangelands and associated agricultural lands. We must be concerned not only for

threatened and endangered species, but also for all migratory species that become exposed to grasshopper pesticides and other control treatments applied to their habitat. In addition to the Fish and Wildlife Service's legal responsibility for migratory birds and endangered species, we should remember that birds and other small wild vertebrates are effective predators on range grasshoppers. Large solid-block treatments that eliminate birds through toxic effects and mortality or mass emigration are self-defeating in the long run. The planned IPM experiments offer an excellent opportunity to obtain statistically reliable data on several important wildlife questions, such as direct impacts on breeding migratory birds, hazards to endangered species, buffer zone requirements, duration of effects on nesting bird populations, degree of acetylcholinesterase inhibition and significance at the population level of different degrees of inhibition, and contribution of birds to grasshopper control in an IPM system.

7. OBJECTIVES: There are several objectives of this research as listed below. Most objectives will be approached with testable hypotheses and statistically adequate field experiments.

A. Determine the impact of control operations on populations of common species of migratory birds inhabiting the interior of large treatment blocks.

B. Determine the degree of inhibition of acetylcholinesterase (ChE) in birds inhabiting the interior and the edges of large treatment blocks.

C. Determine the percent inhibition of brain acetylcholinesterase in kestrels and 2-4 common species of migratory birds and fish within treatment blocks.

D. Determine treatment buffer zone requirements to protect critical migratory bird habitats such as foraging territories of nesting peregrine falcons.

E. Measure impacts on nestling growth and survival, adult bird foraging time,

and food habits changes related to reduction in insect food base from broad-spectrum insecticides.

F. Determine relative pesticide exposure of nontarget migratory birds inhabiting large areas treated with liquid spray vs. large areas treated with bran baits.

G. Make direct observations of treatment impacts, if any, on the migratory bird species considered to have unstable or declining populations in U.S. Fish and Wildlife Service Regions 1 and 6 when any of those species are present on treatment areas.

H. Measure grasshopper predation by birds and other wild vertebrates and develop models of contribution to grasshopper mortality at different life stages and under different conditions.

I. Determine mortality of wild vertebrates in relation to grasshopper control treatments.

J. Conduct a pilot study of acute oral toxicity of acephate and methamidophos to kestrels in the field.

K. Collect and preserve terrestrial and

aquatic samples for chemical analysis per the Gulfport Laboratory protocols and ship them as scheduled by USDA-APHIS.

8. PROCEDURES: The following procedures will each relate to the objective with the same letter.

A. Hypothesis: Posttreatment census trends of breeding birds inhabiting the center 4 sections of a 10,000 acre (or larger) treated area will not differ from the same species nesting in comparable untreated areas. Bird censuses will be conducted by the line transect method of Burnham et al. (1981). A minimum of 5 replicates will be established per treatment and in comparable untreated habitat. Each permanently marked transect will be censused 2-3 times prior to treatment and 3-4 times through at last 28 days post-treatment. Untreated plots and transects will be run concurrently. Transects will be of uniform lengths and will be sufficiently long to yield a minimum of 40 observations per common species. Transects will be located in mixed

grass prairie in North Dakota (Shaver, 1977, p. 19) and in the sagebrush-wheatgrass type in Idaho (Bailey, 1978). In succeeding years of the project a large number of common breeding birds could be marked with small transmitters and/or color markers to study mass emigration from large treatment blocks.

B. Hypothesis: Mean brain ChE activity in nesting migratory birds inhabiting the interior of large chemical spray blocks will not differ from the same species nesting near the edges and in untreated areas > 5 miles away.

The IPM Plan calls for treatment of 100,000 acres per year in blocks $\geq$ 20,000 acres. For acetylcholinesterase measurements, we will collect birds by shooting or trapping from separate treatment blocks away from the population census plots. Each bird species under study (3 or 4 of the most common nesting migratory species) will be collected periodically in sufficient numbers (10-14 per species per period) to establish sta-

tistically valid mean brain ChE activity. Collections will continue until the species has returned to within $\pm$ 20% of normal ChE activity. Specimens of the same species (only adult birds in all cases) will be collected from untreated areas in the same time periods to establish normal brain ChE activity.

C. Hypothesis: Mean ChE inhibition is not correlated with productivity (mean number of young fledged), survival of adult breeding birds, or emigration from treatment blocks. Birds will be collected in adequate numbers from the three types of areas for brain ChE comparisons. Nests of 1 or 2 of the most common species will be located, marked, and directly observed to see the behavior of adults caring for eggs or nestlings. Activities and time at the nest will be quantified. Most of the specimens collected will serve for both Objectives B and C. The brain ChE data will provide data for buffer zone requirements.

D. Hypothesis: Breeding American kestrel behavior and nesting productivity does not change with distance (0 to > 10 mi) from the treatment boundary. Nest boxes will be established to attract American kestrels. Kestrels are small falcons that nest throughout the western states and can be attracted to wooden nest boxes of appropriate design and placement. Nesting kestrels are tenacious and tolerate periodic examination of eggs and young. Clutch size, percent eggs hatched, growth of young, number fledged, and food habits will be measured. Study of kestrels nesting at different distances from the of a chemical spray treatment, as well as within the sprayed area, would provide the first quantitied observations on effects of the chemical and the width of buffer zone necessary to protect endangered raptors. [The project leader is currently using the kestrel nest box technique to determine insecticide effects in another study and has also used the method in a previous experiment.]

E. Hypothesis: Nest attentiveness, foraging time, and proportion of animal material in the diet of 1 or 2 common passerines will not differ between treated and untreated areas. Bird specimens collected for brain ChE measurements (10-20 per species per sampling period) will also be utilized for food habits examination of stomach contents (as per McEwen et al. 1986). Birds directly observed at their nest for Objective C will also provide data for this objective.

F. Hypothesis: Brain ChE activity measurements and pesticide residues in stomach contents of birds will not differ between untreated areas and and areas treated with carbaryl liquid spray or bran bait. Two to four common breeding bird species will be collected from the interior of large blocks treated by the two methods. Ten to twenty specimens of each species will be collected per sampling period. Stomach contents of each specimen will be preserved quickly by deep freezing for later

chemical analysis to measure insecticide concentrations.

G. Special efforts will be made to locate and observe the species of migratory birds considered to have unstable or declining populations in U.S. Fish and Wildlife Service Region 1 (IPM areas in Oregon and Idaho) and Region 6 (North Dakota and Wyoming). Many of the listed species can be expected to inhabit the planned IPM treatment areas. These include the Northern Harrier, Ferruginous and Swainson's Hawks, Long-billed Curlews, Burrowing and Short-eared Owls, Loggerhead Shrikes, and Grasshopper Sparrows. Several other of the listed species will probably also be found. Records of observations will be kept of all the listed species. Most will probably be present in numbers too low for statistical analysis, but case histories will be possible in relation to treatments.

H. Hypothesis: Grasshopper predation by birds and small mammals is not significant in relation to other bio-

logical mortality factors regulating grasshopper populations. Food habits studies conducted in other phases of this project will also provide data on grasshopper predation and consumption by the nesting birds. These data can be coupled with information available in the literature on breeding bird population densities, energetics, and proportion of grasshoppers in their diet, to estimate predation. Models can be developed for major vegetation types and range condition classes, seasonal changes, and different complexes of nesting bird species (guilds). These models will be useful to the entomologists developing effective IPM practices and will help show the role and value of birds in healthy rangeland ecosystems.

I. Establish systematic carcass survey routes and transects to determine wildlife mortality before and after treatments and on untreated areas. The methods of Balcomb et al. (1984) and DeWeese et al. (1983) will be modified for rangeland use.

J. Wild adult kestrels using nest boxes will be given single oral dosages of acephate or methamidophos to determine the field LD_{50}'s. Treated birds will be observed for toxic effects as was done with wild prairie grouse by McEwen and Brown (1966).

K. Animal and environmental samples for chemical analysis will be collected in proximity from each sampling area so that they can be related to each other (i.e., soil-plants-insects-wild vertebrates and similarly in aquatic habitats).

9. LITERATURE CITED:

Bailey, R.G. 1978. Description of the ecoregions of the United States. USDA-Forest Service, Ogden Utah. 79 pp. + maps.

Balcomb, R., C.A. Bowen, II, D. Wright, and M. Law. 1984. Effects on wildlife of at-planting corn applications of carbofuran. J. Wildl. Manage. 48:1353-1359.

DeWeese, L.R., L.C. McEwen, L.A. Settimi, and R. D. Deblinger. 1983. Effects on birds of fenthion aerial application for mosquito control. J. Econ. Entomol. 76:906-911.

McEwen, L.C. and R.L. Brown. 1966. Acute toxicity of dieldrin and malathion to wild sharp-tailed grouse. J. Wildl. Manage. 30:604-611.

McEwen, L.C., L.R. DeWeese, and P. Schladweiler. 1986. Bird predation on cutworms (Lepidoptera: Noctuidae) in wheat fields and chlorpyrifos effects on brain cholinesterase activity. Environ. Entomol. 15:147-151.

Shaver, J.C. 1977. North Dakota rangeland resources. Soc. for Range Manage. Old West Regional Comm., N. Dak. State Univ., Fargo, ND, 188 pp.

10. PROGRESS REPORTS AND OUTPUTS:

Institution project personnel shall:

A. Make quarterly reports on the progress of the work and other reports as may be desired by the cooperating parties, but not fewer than one oral and one written progress report annually, including at the termination

of the project one oral and one written report both of which shall report substantive findings and analytical results, as well as describe research progress.

B. Include in the final written report an explanation of the estimating methods and procedures used.

C. Make available to the Service copies of models of insect predation by birds that are developed. The models shall be in a form consistent with the Service's computer system.

11. RESPONSIBILITIES ASSUMED:

A. <u>The Institution agrees</u> to:

1. Assign a Senior Research Scientist from its faculty to serve as project leader for the evaluation of effects on fish and wildlife found in the grasshopper IPM treatment areas.

2. To assign one Professor, one Assistant Professor, and three Research Scientists in Fishery and Wildlife Biology and one Scientist in the Natural Resource Ecology Laboratory to assist in

all phases of the fish and wildlife evaluations.

3. To assign three Graduate Research Assistants to the field work and portions of the laboratory work as needed.
4. Provide the necessary office space, laboratory facilities, communications, and clerical supplies for personnel assigned to the project.
5. Provide biometrical advice and assistance for study design and sampling needs.
6. Provide for the use of data processing and computer equipment by personnel assigned to the project at the institution.
7. Provide 29.9% of the Indirect Costs estimated to be 39.9% in total.

B. The Service, through its [Office/Division/Branch], shall:

1. Administer the Cooperative Agreement for fish and wildlife evaluations.
2. Pay travel and per diem expenses

for Service and Institution employees.

3. Assist in defraying the cost of the project by reimbursing the Institution for direct project costs indicated on Appendix A of this Agreement; however, funds provided by the Service to the Institution will not exceed $214,324 in FY-87. Funding in succeeding years will depend on annual appropriations of funds.

12. MUTUAL AGREEMENTS:

A. Computer programs written and data cards/tapes prepared under this Agreement, the cost of which is reimbursed by the Service, are and shall remain the property of the Service, but will be available for use by the Institution. All programs shall be written in either COBOL, FORTRAN, or in languages compatible with microcomputers as mutually agreed.

B. To obtain reimbursement the Institution shall submit to the Service Standard Form _____ or comparable

document. The request for reimbursement may be submitted monthly or quarterly to the Service.

C. Attached as Appendix A is a budget of estimated expenditures for the period of the Agreement, which will serve as a planning and management device, though not as a fiscal document.

D. Unless specifically authorized elsewhere in this Agreement, reimbursement will not be allowed for nonexpendable equipment, real property and capital improvement, and other assets.

E. Progress reports, outputs, and requests for reimbursement will be sent to the following:

[Name and address to be supplied]

Prospectus of Proposed Research

Title: Effect of large-scale range grasshopper IPM projects on aquatic systems

Personnel: Principal Investigators:

Clarence A. Carlson, Professor in Fishery Biology and Administrator, Larval Fish Laboratory

Robert T. Muth, Research Associate and Assistant Administrator, Larval Fish Laboratory

Department of Fishery and Wildlife Biology

Colorado State University, Fort Collins

To be selected: Two Graduate Research Assistants, CSU; one for the first half of the project, and the other for the second half.

Sponsor: U.S. Department of Agriculture, Agricultural Research Service

Introduction:

The Animal and Plant Health Inspection Service's (APHIS) Integrated Pest Management (IPM) grasshopper program experiments and demonstration provide an unique opportunity to study impacts on nontarget wildlife. Two areas (U.S. Bureau of Land Management land in Idaho and a tract in McKenzie County, North Dakota) will receive treatments of carbaryl, malathion, and acephate sprays; carbaryl bait; and Nosema, a biological control agent, over the next five years. In each of these areas, at least 20,000 acres will be exposed to each of the treatments. The U.S. Fish and Wildlife Service, which is participating in the program on an advisory basis, has stated that

it is concerned about possible adverse impacts of spraying on threatened and endangered (T/E) species and on the population status of passerine birds. Fish and Wildlife Service concerns extend to continuing grasshopper and Mormon cricket control programs in Colorado and Utah. Questions regarding the nature of monitoring programs and the size of buffer zones necessary to protect T/E species must be resolved, and well-designed studies of aquatic systems will be needed to acquire information to remove T/E fish and T/E birds which prey upon fish from jeopardy.

The Larval Fish Laboratory at Colorado State University (CSU) has extensive experience with threatened and endangered fishes of the Upper Colorado River System, where collecting can be fraught with difficulties and dangers, and is expert in identifying and handling fish early life stages, which are particularly susceptible to water quality changes. It is uniquely qualified to conduct research which can provide information on impacts of grasshopper and Mormon cricket control programs on aquatic systems. Research with the following objectives is proposed.

Objectives:

1. To survey, early in the period of work, literature on occurrence and possible causes of lordosis in fishes and on effects of malathion, acephate, and carbaryl on aquatic life.

2. To determine pesticide residues in water, sediment, aquatic insects, crayfish, and selected common species of fish collected before and after treatment in waters in treated and untreated portions of APHIS IPM experimental areas and near Dinosaur National Monument, Colorado and Utah.

3. To determine brain acetylcholinesterase (ChE) levels in selected fish species collected before and after treatment in waters of treated and untreated portions of the above-mentioned areas.

4. To determine, by laboratory bioassays, concentrations of malathion, acephate,

and carbaryl associated with mortality, lordosis (if any), and various brain ChE levels in the same fishes.

5. To determine the incidence of lordosis in larval and juvenile roundtail chub in the Yampa and Green rivers, Colorado and Utah, near Dinosaur National Monument before and after spraying for Mormon cricket control.

6. To determine relative abundance of aquatic macroinvertebrates before and after treatment in waters of treated and untreated portions of the above-mentioned areas.

Methods:

Most information in this study will be obtained by collecting samples in areas to be treated for grasshopper or Mormon cricket control in North Dakota, Idaho, and Colorado-Utah; analyzing samples for pesticide residues; analyzing brain ChE levels in collected fishes; using collected fishes in standard laboratory toxicity tests; determining incidence of lordosis in field-collected roundtail chub; and analyzing numerical abundance of aquatic macroinvertebrates in samples collected in a standardized fashion. The investigators propose to conduct all of the research except determination of pesticide residues, which will be done by APHIS laboratories. Collections needed to achieve objectives 2,3, and 6 will be made each year in the IPM areas and near Dinosaur National Monument. Other research (to achieve objectives 4 and 5) will be concentrated on carbaryl and roundtail chub during the first half of the period of work and on all three pesticides and selected common fishes of the IPM areas during the second half of the research period.

Water, sediment, macroinvertebrates, and fishes will be collected and preserved as necessary for pesticide residue analysis (as directed by APHIS) from the Yampa and Green rivers and from selected waters in the IPM areas in North Dakota and Idaho before and after spraying each year. Fishes will be collected by electrofishing, gill

nets, seines, and/or dip nets, depending on the habitats samples. Collection locations and times will conform to an experimental design approved by all cooperators. All life stages of fishes selected for brain ChE analysis will be collected and returned to CSU, where brain ChE activity will be determined in the Laboratory of Dr. Lowell McEwen. Incidence of lordosis in larval and juvenile roundtail chub (a close relative of the endangered bonytail and humpback chub, and the Upper Colorado River System fish in which lordosis was first noted in 1980 by investigators from CSU and the Colorado Division of Wildlife) will be determined in the Yampa and Green rivers by sampling in July through September of the first two years of project work. Early life stages of roundtail chub will be obtained and subjected to standard early life toxicity tests involving carbaryl during the first half of the period of work; concentrations of carbaryl causing mortality and lordosis will be determined. Fishes exposed to various concentrations of carbaryl in these tests will be analysed for carbaryl residues in tissues and brain ChE levels. Similar data will be collected on responses of selected common fishes of the IPM areas to carbaryl, malathion, and acephate during the second half of the period of work. Stream macroinvertebrate samples for determination of relative abundance will be collected by standard means according to an experimental design approved by all cooperators before and after spraying from the Yampa and Green rivers and selected waters of the IPM areas. Samples will be analyzed in the laboratory at CSU.

Work schedule:

Project work will be conducted from Spring, 1987, until 30 September 1991. Field work will be concentrated in spring and summer months. Other periods will be devoted to planning, literature work, laboratory experiments, specimen and data analysis, report preparation, and satisfying requirements for M.S. degrees.

Supervision:

Research of Graduate Research Assistants will be supervised by both of the Principal Investigators with input from cooperating biologists. Graduate student academic progress will be supervised by Dr. Carlson.

Products:

Annual reports on project progress will be prepared and submitted to the U.S. Department of Agriculture. Other periodic reports desired by cooperators will be provided. Results of the study will be the basis for two theses prepared in partial fulfillment of requirements for M.S. degrees in Fishery and Wildlife Biology at CSU, and manuscripts will be prepared for submission to appropriate professional journals. A final written report will be submitted to the Department of Agriculture at the conclusion of project work.

Budget:

The research is expected to require annual funding at a level of approximately $40,000. A tentative budget of $38,768 for the first year of work, including salary for the first graduate student, the co-principal investigators, and assistants; provision for equipment, supplies, travel, and publication costs; Larval Fish Laboratory administration fees; and CSU overhead has been incorporated into the total budget. CSU will provide offices for personnel, laboratory space, most lab equipment, computer time, library facilities, and most field equipment. It is assumed that APHIS will determine residues of carbaryl, malathion, and acephate in samples collected by the researchers.

Preparation of a Research Proposal:

The Principal Investigators will complete a formal proposal and a definitive project budget upon request.

Appendix D
Comments and Responses to the Draft EIS

INTRODUCTION

Since the draft EIS was published in November 1986, APHIS has received comment letters from the general public, organizations and corporations, universities, and Federal, State, and local agencies. Although the deadline for the comment period on the draft EIS was December 22, 1986, many letters were received after this date. In preparing the final EIS, APHIS continued to consider and respond to all comments that were received up until January 16, 1987, after which the production schedule would allow no further delay.

This appendix contains a list of all commenters (table D-1), a reproduction of all comment letters, and APHIS' response to each comment. Attachments and addendums to all comment letters were also considered in preparing the final EIS; however, they have not been reproduced in this appendix. Such attachments are filed in the administrative record and are available for public review at APHIS. Each comment letter was assigned an identification number, which appears in the upper right-hand corner of each page. Comments were then numbered in two-digit codes sequentially within each letter; these numbers appear to the left of each individual comment. The first digit refers to the comment letter identification number, and the second digit refers to the individual comment within that letter. For example, the code 2-2 in the letter margin refers to the second comment in comment letter 2.

Responses were given two-digit codes corresponding to the comment letter and each specific comment within that letter, as explained above. All responses appear at the end of this appendix following the comment letters. Responses are generally of three kinds: (1) a statement that the text has been revised in accordance with the comment, (2) an explanation of why the text has not been revised in accordance with the comment, or (3) a clarification of issues peripherally related to the analysis of the EIS but outside its scope. If several commenters raised the same issue, APHIS generally responded to it only once and then referred to that original response when the issue arose again, rather than repeating the response.

Comment letters on the draft EIS received from EPA and the Department of the Interior follow those received from the public. They are assigned identification letters A and B. Comments and responses to these letters are coded in the same manner previously described for the other letters.

Table D-1--List of commenters on the draft EIS

Letter Identification Number	Commenter	Location
1	R.I. Sullivan Colorado Department of Agriculture, Division of Plant Industry	Denver, CO
2	Everett W. Spackman University of Wyoming, Cooperative Extension Service	Laramie, WY
3	Allen Mooney Campbell County Weed and Pest District	Gillette, WY
4	Jeffrey A. Lockwood University of Wyoming, College of Agriculture	Laramie, WY
5	Norma Grier Northwest Coalition for Alternatives to Pesticides	Eugene, OR
6	Jason Marks Sierra Club Legal Defense Fund, Inc.	Denver, CO
7	Tom Collazo Huachuca Audubon Society	Sierra Vista, AZ
8	Francis Petera Wyoming Game and Fish Department	Cheyenne, WY
9	Janet Ocrowley	Picabo, ID
10	John Orton Wyoming Department of Agriculture	Cheyenne, WY
11	Shirley A. Briggs Rachel Carson Council, Inc.	Chevy Chase, MD
12	Robert E. Pfadt University of Wyoming, College of Agriculture	Laramie, WY

Table D-1 (continued)--List of commenters on the draft EIS

Letter Identification Number	Commenter	Location
13	John Evans Evans BioControl, Inc.	Durango, CO
14	Robert R. Benjamin Sheridan County Weed and Pest Control District	Sheridan, WY
15	Kirk M. Barnette Big Horn County Montana Grasshopper Control Committee	Hardin, MT
16	Robert B. Shoemaker Platte County Weed and Pest Control District	Wheatland, WY
17	John A. Kwiatkowski U.S. Department of the Interior, Bureau of Land Management	Billings, MT
18	Edison Stephens Paul R. Daniels Al Rivas Utah Department of Agriculture	Salt Lake City, UT
19	Harold F. Olson New Mexico Department of Game and Fish	Santa Fe, NM
20	Linda S. Craig Audubon Society of Portland	Portland, OR
21	Jimmy Krsnak South Dakota Department of Agriculture, Division of Regulatory Services	Pierre, SD
22	Don Meike Peter Meike and Sons, Inc.	Kaycee, WY
23	George F. Hittle Wyoming Department of Agriculture	Cheyenne, WY

Table D-1 (continued)--List of commenters on the draft EIS

Letter Identification Number	Commenter	Location
24	Duane L. Shroufe Arizona Game and Fish Department	Phoenix, AZ
25	Ken Hamilton Wyoming Farm Bureau	Laramie, WY
26	Bill Wright Oregon Department of Agriculture	Salem, OR
27	Keith Kelly Montana Department of Agriculture	Helena, MT
28	William P. Stephens New Mexico Department of Agriculture	Las Cruces, NM
A	Richard E. Sanderson U.S. Environmental Protection Agency	Washington, DC
B	Bruce Blanchard U.S. Department of the Interior	Washington, DC

COMMENTS

All comment letters received by January 16, 1987, are reproduced here. Responses to the comments begin on page D-69.

1

STATE OF COLORADO

DEPARTMENT OF AGRICULTURE
1525 Sherman Street
Denver, Colorado 80203
(303) 866-2811

DIVISION OF PLANT INDUSTRY
Telephone (303) 866-2838

Richard D. Lamm
Governor
Timothy W. Schultz,
Commissioner
Donald Rolston
Deputy Commissioner

November 12, 1986

Mr. Charles H. Bare, Staff Officer
PPQ, APHIS, USDA
Federal Building, Room 663
Hyattsville, Maryland 20786

Dear Mr. Bare:

The Draft Environmental Impact Statement for the 1987 Rangeland Grasshopper Cooperative Management Program does not recognize the need for retreatment of areas where rainfall has washed the spray material away shortly after application.

Leaving an area within the control block with high populations of grasshoppers would well negate the effectiveness of a project.

It would be well to include provisions for handling such situations.

Very truly yours,

R.I. Sullivan

R. I. Sullivan, Director
Division of Plant Industry

RIS:eg

cc: Les Zermuehlen, Chief
Nursery, Seed, Apiary & Pest Control Districts Section

Otha Barham, Officer-In-Charge
PPQ, APHIS, USDA
Wheatridge, CO

RCVD. FOSS 11/18/86

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Cooperative Extension Service

College of Agriculture
The University of Wyoming

Administrative Offices
P.O. Box 3354
Laramie, WY 82071
(307) 766-5124

November 24, 1986

Charles H. Bare
Staff Officer
PPQ-APHIS-USDA
Federal Building, Room 663
Hyattsville, MD 20782

Dear Mr. Bare:

I would like to make some comments on the Draft Environmental Impact Statement on the Rangeland Grasshopper Cooperative Management Program, APHIS-DEIS 86-1.

2-1 Under Operational Procedures page 2-30 there are some statements pertaining to the protection of bees. Part 14-d "Do not apply acephate, carbaryl, or malathion to any blooming crops or weeds or allow it to drift onto blooming crops and weeds if bees are visiting the area." This is a restriction that is so broad that it would be almost impossible to carry on a grasshopper control program under this requirement. There is probably very few crops or weeds in bloom where one could not find a bee.

2-2 The other comment I have pertains to the use of Nosema locustae page 2-16, 17. The research results from experiments conductec by R. E. Pfadt, Entomologist (retired), University of Wyoming does not indicate it to be a product to depend on for rangeland grasshopper control. Where were the five studies that were mentioned by Wright conducted (page 2-17 second paragraph)?

Sincerely,

Everett W. Spackman

Everett W. Spackman
Extension Entomologist

EWS:kds
cc: John Larsen, APHIS, Cheyenne

RCVD. FOSS 12/2/86

3

Campbell County Weed and Pest District

BOX 191 :: PHONE 682-4369
Gillette, Wyoming 82716

DEC 10 1986

PGS	
CAH	MJS
DRT	CHB
LHT	GEM
OKB	RGS
	TGF
File:	Date: 12-10-86

December 4, 1986

TO: Charles H. Bare, Staff Officer
PPQ-APHIS-USDA
Federal Building, Room 663
Hyattsville, MD. 20782

FROM: Campbell County Weed & Pest
P.O. Box 191
Gillette, Wyoming 82716

SUBJECT: Rangeland Grasshopper Cooperative Management Program
Draft Environmental Impact Statement-1987

Campbell County Weed & Pest has the following comments concerning the draft EIS-1987. Our concerns are in table two--Operational procedures(Page 2-30)under Ultra-Low-Volume Aerial Application(Chemical Methods), item 10 and item 14,d.

3-1 Item 10, indicates that ULV's cannot be applied within 500 feet of any body of water that is identified within the operation area, including reservoirs, lakes, ponds, springs, and perennial streams or rivers. The word, "any" in this statement could be interpreted to include any stock watering tanks and or pits. If this operational procedure is drafted in the final EIS as it now reads there would not be any area in Campbell County that could be effectively sprayed.

3-2 Item 14,d, whereas ULV's cannot be applied to any blooming crops or weeds if bees are visiting the area will by itself delete Campbell County and the rest of Wyoming from any type of effective grasshopper spraying program. There are many species of weeds within the county-very few of which bloom at the same time. If precautions are taken as outlined in 14 a,b,c it would seem that 14,d could be deleted or at least remove the word, "weeds" where it appears in 14,d.

Campbell County, Wyoming has an estimated infestation of 1,359,360 acres based on the adult grasshopper survey. Campbell County ranchers are indeed concerned about the above mentioned operational procedures. If they are accepted as written a successful control program would be highly unlikely.

Sincerely,

Allen Mooney
Allen Mooney, Supervisor

Lynn Smith Board member
James A. Ward Board member
David A. Dick Board member
John C. [illegible] Chairman
J. Kawulok Board Member

4

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College of Agriculture

The University of Wyoming
James K. Wangberg, Head

Department of Plant Science
PO Box 3354
Laramie, WY 82071
(307) 766-3103

DEC 10 1986

PGS	
CAH	MJS
DRT	CHB
LHT	GEM
OKB	RGS
	TGF
File:	Date: 12-10-86

December 1, 1986

Charles H. Bare
Staff Officer
PPQ-APHIS-USDA
Federal Building, Room 663
Hyattsville, Maryland 20782

Dear Mr. Bare:

I have reviewed the Draft Environmental Impact Statement - 1987, for the Rangeland Grasshopper Cooperative Management Program. While the majority of the document appears to be reasonable and substantiated, there are a few areas that I believe are misrepresented.

4-1 First, the consideration of *Nosema locustae* as a biological control agent seems unjustifiably optimistic. While an environmentally safe, ecologically sound, economically viable, and highly efficacious control method is a desirable goal, I do not believe that the scientific literature demonstrates that *Nosema* is such an agent. Indeed, environmental safety appears to be its only established quality to date. With regard to specific references, on page xxi and 2-2, it is stated that *Nosema* is most effective in a preventive approach to outbreaks. There is no documentation provided for this claim and to my knowledge *Nosema* has yet to be used in this capacity. While applications may be desirable, this concept is not presented as speculation, which, in fact, it is.

4-2 On page 2-2, it is stated that up to a 50% reduction in grasshopper populations can occur following *Nosema* treatments, and (page 2-3) the residual protection may continue for one or more years following treatment. Besides being unreferenced, these claims ignore other possibilities. In some cases, no reduction in a population follows *Nosema* application and residual protection may be nonexistent (Henry and Onsager 1982). While Henry and Onsager (1982) found some indication of extended control in one treatment, the use of elaborate analyses in an attempt to correct for confounding variables and the application of liberal statistical boundaries derived after the experiment was conducted (thereby increasing the probability of a Type II error, i.e. drawing a false conclusion, and violating the standard practice of establishing the statistic *a priori*) certainly lead to some doubt of their conclusions.

4-3 The description of Nosema on pages 2-16 through 2-18 is also inaccurate. While Henry (1972) found an infection level of 5% in an enzootic area, this does not represent a normal condition. Henry and Onsager (1981) clearly state that upon examination of thousands of grasshoppers throughout the western U.S., the frequency of infection among adults was considerably less than 1%.

4-4 The statement regarding a 5% transmission rate in the laboratory (page 2-17) is not referenced and its applicability to the field should not be assumed.

4-5 It is not clear why current studies in which Nosema has been used to control heavy infestations are a worst-case scenario (page 2-17) if, in fact, the pathogen is most effective at densities of 15 to 22 grasshoppers/yd^2. The proposed early use of Nosema to prevent outbreaks would seem to be the potential worst case since the pathogen performs poorly in low population densities. There is no reference to the speculation that Nosema is most effective if introduced early; the existence of such data would contradict the assertion that, "To date, tests of Nosema have attempted to suppress heavy infestations...".

4-6 While available data (again unreferenced) may indicate that infected individuals survive 4 to 6 weeks (page 2-17), it is not clear that this differs from the survival of uninfected individuals under natural conditions.

4-7 Reference to Wright (1985) is virtually useless (page 2-17 and elsewhere) since his report is apparently an unavailable memorandum.

4-8 In the referenced study of Ewan and Mukerji (1979) the application rate was 2.0 billion spores/acre ($5x10^9$ spores/ha ÷ 2.47 acres/ha), not 4.5 billion spores/acre. It is also not clear why this study was chosen rather than that of Henry (1971) where infections in various species ranged from only 5 to 56% following treatment.

4-9 The last sentence in paragraph 3, page 2-17 is misleading. In the year after treatment all of the first collection of nymphs had trace levels; very few insects were ever found to be infected at higher than trace levels, and of those that were, all were adults collected in July. The trace infection was probably of no importance in regulating the population in the second year. Moreover, the authors concluded that, "N. locustae can carry over to the next season, but perhaps not in quantity enough to have any substantial effect on the next year's population." There is also in this section of the report, no consideration of Henry and Onsager's (1982) study which showed 0.8 to 2.7% infection in the year following a high treatment ($8.5x10^8$ spores/acre) and 0 to 4.5% infection in the year following a low treatment ($8.5x10^7$ spores/acre). The reference on page 4-76 to the arguments in Chapter 2 is not legitimate. Clearly, Nosema has also been shown to have no residual effects in the year following treatment.

4-10 The parenthetical statement that species that do not feed on bran can contract Nosema from species that do (page 4-76) is unsubstantiated and the practical effect of such a phenomenon, if it exists, is entirely unknown.

4-11 The statement that the use of Nosema could result in increased damage in the year of treatment (page 4-8) compared to chemical control is true, but it is not the whole story. Pfadt (1977, 1986, in press) has shown that chemical treatments maintain control of grasshopper populations for an average of 5 to 6 years, while it has required elaborate data manipulations to indicate that Nosema lasts even two years (e.g., Henry and Onsager 1982). Thus, the increased damage caused by the use of Nosema versus a chemical method almost certainly extends well beyond the year of treatment.

4-12 Finally, the contention that carbaryl or Nosema baits would be the control methods of choice in a sensitive area, regardless of timing, is an untenable position (page 2-25). If the treatment is late in the season, neither of the suggested methods is a viable means of grasshopper control. The use of malathion would surely be more sensible if the animals in the sensitive area were not realistically threatened by malathion (as indicated for some of the organisms in Table 4-14 and elsewhere).

4-13 A second potential problem with the document as it stands is restriction 10 on page 2-30. A body of water needs to be defined. It would be unreasonable to include stagnant puddles, ephemeral ponds, stock tanks, etc. Such potential bodies of water support few species and no viable communities.

4-14 The consideration of drift in context of protecting water is vague; on page xxii, it appears that the 500 ft boundary is a fixed zone that will not be corrected for wind or drift. In windy areas, i.e. most of Wyoming, a strict 500 ft boundary without consideration of drift would seem to virtually negate the intended protection of bodies of water. However, this may not be a severe problem since direct spraying of lakes and streams seems to have little appreciable long-term impact on these habitats (4-43 through 4-45).

4-15 A final matter of concern is restriction 14d on page 2-30. To prevent chemical drift or application on blooming crops or weeds, if bees are visiting the area, is ambiguous and impractical. Aside from problems of defining the terms, "weed" and "visiting", there seems to be no reason to preferentially protect all bees. While it is certainly sensible to protect apiaries and domestic bees, the blanket protection of all foraging bees is unfounded. Wherever there are flowering plants there almost certainly will be bees, so the restriction essentially prevents treatment of all blooming crops and weeds. It would seem more reasonable to restrict applications to blooming crops and weeds in a given radius around apiaries. This would protect the apiculturalists' concerns and still allow protection of the ranchers' and farmers' investments.

4-16 It is my hope that we will develop control strategies with increasing ecological safety. I think that IPM efforts are a meaningful move in this direction. Until such an ideal method is discovered, it is essential that we use existing methods in the most environmentally rational manner possible. I would advocate the use of baits when they are practical and the use of chemical sprays only when they are necessary. However, in the move to environmentally responsible management practices, we must be careful to adopt methods only after critical examination and to restrict methods only when such limitations produce the desired benefits.

Thank you for your consideration of my letter. If there are any questions regarding its content, please do not hesitate to contact me.

Sincerely,

Jeffrey A. Lockwood
Assistant Professor

JAL/kds

cc: J. Larsen
W. Patch
E. Spackman
J. Wangberg

5

NCAP
NORTHWEST COALITION for ALTERNATIVES to PESTICIDES
P.O. BOX 1393 EUGENE, OREGON 97440 (503) 344-5044

December 22, 1986

Mr. Mike Shannon
PPQ-APHIS-USDA
Federal Building
Hyattsville, MD 20782

Dear Mr. Shannon:

Enclosed are the NCAP comments on the Rangeland Grasshopper Cooperative Management Program Draft Environmental Impact Statement.

As you indicated on the phone, these comments will be included in the final document since I am mailing them to you overnight with a December 22 postmark.

Thank you very much and happy holidays.

Sincerely,

Norma Grier

5

NORTHWEST COALITION for ALTERNATIVES to PESTICIDES
P.O. BOX 1393 EUGENE, OREGON 97440 (503) 344-5044

COMMENTS ON THE RANGELAND GRASSHOPPER COOPERATIVE MANAGEMENT PROGRAM DRAFT ENVIRONMENTAL IMPACT STATEMENT

December 20, 1986

Charles H. Bare
Staff Officer
PPQ-APHIS-USDA
Federal Building, Room 663
Hyattsville, MD 20782

Dear Mr. Bare:

The following comments are submitted on behalf of the Northwest Coalition for Alternatives to Pesticides. Although there is marked improvement in the DEIS from previous years' documents, the DEIS is still deficient in several ways.

Most importantly, the DEIS does not adequately develop the alternatives that are considered in the EIS. NEPA regulations clearly state that the alternatives, including the proposed action, are the "heart of the environmental impact statement". 40 CFR 1502.14. For a programmatic EIS covering large acreage and using pesticides, the alternatives must "[u]se all practicable means, ...to restore and enhance the quality of the human environment and avoid or minimize any possible adverse effects of their actions upon the quality of the human environment." 40 CFR 1500.2 (f).

5-1 Specifically, the preferred alternative in the DEIS is described as a long-range integrated pest management (IPM) alternative. The DEIS gives lip service to some concepts of IPM, but fails to advance a thorough, well-conceived alternative that will allow local managers to operationalize IPM in grasshopper management programs.

The definition of IPM is given in several locations. In the summary (p. xv), the definition includes the concept of a systems approach to management. Unfortunately, APHIS then proceeds to unabashedly ignore any reference to a systems approach to management and describes the implementation of IPM to be a matter of selecting methods of control. This falls short of the comprehensive decisionmaking process that IPM provides. IPM is not just a mix of methods or a choice of methods.

Two other definitions of IPM also fall short of including a sustems approach to management. The definition given at the start of the chapter on alternatives (p. 2-2) states that IPM is a mix of methods. Even in the detailed description of the alternative (p.2-15) the emphasis is on methods of control. APHIS must do some more thinking to develop the IPM alternative so that the public is assured that a systems approach is implemented.

5-1 The APHIS preferred alternative does provide for consideration of economic, ecological, and sociological consequences, but those considerations are only invoked in relation to the various methods of control. The "systems" approach in classical IPM refers to the entire decisionmaking process, not just the fourth step in the process (i.e., selection of techniques).

As it is classically described by Robert van den Bosch and Mary Louise Flint[1], IPM is a five step decisionmaking process including (1) monitoring, (2) setting of injury levels, (3) setting of action levels, (4) selecting effective treatments that are least disruptive of the environment and least harmful to human health, and (5) evaluating the effects of the program on the target pest and the environment. NCAP is convinced that adoption of this five step process will provide the framework necessary for an IPM program that truly is a systems approach.

(1) The IPM alternative in the DEIS needs to further develop monitoring.

The DEIS uses the term "surveying" to describe the first function of the APHIS program. At present, the DEIS elaborates on survey techniques for grasshoppers alone. IPM calls for more thorough environmental monitoring in order to have data on which to base decisions. The DEIS refers to collection of some environmental data in the nymphal survey (p. 1-6), but there is scant assurance as to how this information will be used in making decisions.

5-2 Grasshopper management has suffered and failed when grasshoppers are isolated from their surroundings and only methods for killing them are assessed. IPM considers grasshoppers as they relate to the other plants, insects, animals, and resources that surround them. IPM puts a major emphasis on prevention as the first line of defense in management of grasshopper populations. This approach demands that decisionmakers look to the cause of a problem infestation rather than merely seeking to treat symptoms.

In addition to data identified in the EIS on page 1-6 (i.e., weather, the stage of grasshopper biological development, location of grasshoppers and sensitive areas, condition of the rangeland in relation to grasshopper numbers, and the extent of the infestation), data must be collected that identifies current

5-2 and historical use patterns of the land, soil conditions, animal-insect signs other than grasshoppers, plant species, and habitat.

5-3 A specific process must be spelled out in the grasshopper EIS to direct local decisionmakers as they develop programs tiered to this EIS. The public also needs assurance that APHIS's IPM alternative, when it is operating, is actually including all components of the rangeland ecosystem in its decisionmaking process.

(2) The IPM alternative must set accurate injury levels.

5-4 The APHIS EIS currently signs what amounts to a blank check for grasshopper control programs. There appears to be incredible leeway in program authorization. This is not acceptable. The public must know that appropriate standards are met before these massive programs are undertaken.

5-5 The EIS injury level for grasshoppers is set at 8 adults for square yard, since this is the figure derived in 1939 "as the level of infestation at which grasshoppers generally begin to compete with livestock for available forage" (p. 1-12) (Emphasis added). On December 5, NCAP requested this document from APHIS through the Freedom of Information Act because it is not readily available in the published literature. NCAP has still not received a copy and has not been able to review the document for the integrity of its conclusions. The use of the words, "generally begin to compete", are highly suspect. The EIS needs more accuracy than this vague statement.

5-6 The public must be assured that programs are being conducted on rangelands that are actually in need of treatment. An arbitrary assignment of adult density as the injury level is unacceptable, whether it be eight adults or two or three times that number. Conditions vary on each site, and the injury level for one area may differ greatly from that of another area. The EIS must clearly identify the criteria for determining injury level on a site specific basis for the programs that will be undertaken under this EIS. The public simply will not accept treatments on sites that have met the APHIS numbers criteria but have not exceeded a quantifiable injury threshold. The injury treshold must be documented and based on an evaluation of data collected during monitoring.

5-7 The EIS economic injury levels also lack specificity and a depth of analysis that should accompany APHIS projects. For example, the section on Need for Control Activities (p. 1-4) cites numerous studies to indicate a consensus on the volume of damage to range forage from grasshoppers. These studies are then used to estimate the dollar figure of forage lost due to grasshoppers. The Hewitt and Onsager, 1983 study projects if all of the grasshoppers' non-consumed forage would have been available to livestock, the economic loss in 1977 was about $393

5-7 million. The authors note on page 205 of their study, however, that "forage lost to grasshoppers has economic implications only if that forage was intended for other purposes." There are benefits to the ecosystem from the grasshopper's foraging style (see p. 1-3) that must be accounted for before such large dollar assignments are imposed.

5-8 The EIS claims that erosion is a greater likelihood in denuded areas and that grasshopper infested areas are adversely affected (p. 1-4). Once again, NCAP has not received the documents requested from APHIS under FOIA in order to check the reliability of these conclusions. However, it would appear that the heavy litter layer and a resulting enhanced soil moisture content (see p. 1-3) could encourage seed to sprout. This would inhibit erosion rather than a promote it.

5-9 The EIS refers to non-economic populations of grasshoppers as "normal" populations. (p. 1-5). This is not a credible term and should be deleted.

5-10 The EIS also claims that the non-consumed foliage is "wasted" by grasshoppers. (p. 1-4). Once again, this term is biased and should be deleted.

(3) The EIS must set appropriate action levels.

The major goal of action in an IPM programs is to prevent injury from occuring. Having gathered comprehensive site data and carefully evaluated under what conditions damage occurs, it is essential that APHIS provide the guidance to identify when to and when not to act. This has clearly not been done.

5-11 Currently, a major criterion for taking action is the written request from the landowner (e.g., see pp. xii, 1-5, and 2-27). With sweeping vagaries about injury levels and the minimal need to document that grasshoppers actually are damaging rangelands, this simple call to action from landowners is and has been a vehicle for major environmental abuse. The EIS fails to assure the public that APHIS will only act when the treatment prevents injury or enables long-term control. Further, the EIS fails to ensure that the IPM program will actually reduce insecticide use.

5-12 APHIS claims that "[w]ithout control, an outbreak may last 3 or more years." (p. 1-2) This statement needs documentation. Do control programs always eliminate outbreaks from occuring in subsequent years? Are there examples of control programs that were not successful at arresting outbreaks in subsequent years?

NCAP's position is not that grasshoppers never do damage. However, APHIS programs that are undertaken with public money on public and private lands to manage grasshoppers must be well-conceived and necessary.

5-13 Another criterion appears to be the size of the site. The EIS claims that a minimum of 10,000 acres that is "workable or flyable" is necessary to make a program "biologically" sound within generally infested areas. (p. 1-10) The "biological soundness" of this criterion is not evident. It appears to be more a "logistical soundness".

5-14 One biological factor for large acreage treatments that the EIS does allude to is migration. (p. 1-1) The EIS discussion lacks specificity as to the conditions under which migration is likely, patterns of migration, and effectiveness of targeted treatments to prevent migration.

5-15 The EIS permits almost any other size program as long as it is an incipient, economically important infestation; a hot spot; or a crop border area of unspecified size involving federal lands. How often and how much cropland is treated under these guidelines?

5-16 The only limiting criterion for action appears to be APHIS' pocketbook. "Cost-sharing depends on funds available to APHIS for conducting grasshopper management program." (p. 1-10) This does not assure the public that well-reasoned programs are being undertaken to ensure long-range control of grasshopper populations.

5-17 APHIS must rework its action levels to reflect the agency's commitment to a long-range integrated pest management alternative. The following are some elements to include in the EIS:

a) Cooperators should be able to demonstrate that they are managing for the long-term sustainability of their lands. They should be able to demonstrate that their management is strengthening those elements in the ecosystem that permit acceptable grasshopper population levels to exist.
b) APHIS must demonstrate that action is designed to prevent grasshopper injury.
c) APHIS must ensure that actions are timed to ensure long-range control.
d) APHIS must ensure that actions are effective for long-term control.
e) APHIS must predict the long-term consequences of actions.

One of the outcomes of an IPM program is the decision not to act. This is a sound decision when monitoring data fail to document a need, when there is uncertainty, or when the consequences of an action are unacceptable.

(4) <u>The EIS's IPM treatments must emphasize prevention and longrange efficacy, be least disruptive of the environment, and pose the least harm to human health.</u>

5-18 The EIS as it is currently written does not achieve these standards. The EIS proposes major reliance on chemical insecticides to contol outbreak populations. Malathion, acephate and carbaryl would be aerially applied in ULV formulations. This is a major concern. Although ULV applications require less volume of active ingredient per acre, the small droplet size promotes offtarget drift that necessarily has unintended and adverse effects on the environment. Little is known about low-level exposures to pesticides and the consequent effects on human and non-human populations.

A recent letter in the <u>Journal of the American Medical Association</u> points to just this fact.[2] <u>Non-specific symptoms in eight women</u> were not recognized as mild, acute pesticide poisoning from off target drift until a physician was able to document disruption of normal nerve function. Their complaints were initially labeled as "group hysteria".

The point is that humans and non-human organisms experience adverse effects when exposed to pesticides. In fact, this EIS predicts that human populations could be exposed at rates above the ADI in numerous situations and in some cases exposure would be above a NOEL. The way APHIS handles this information is dreadful. The inaccuracies in the DEIS warrant a complete reassessment for this section on risk assessment.

5-19 For example, Table 4-21, Human Exposure to Malathion, (p. 4-54) estimates exposures greater than the ADI for accidental worker exposures from direct spraying, a spill of concentrate, and accidental public exposure resulting from a direct sraying of a child, direct spraying of an unregistered crop, and a jettison of an aircraft load into a reservoir. Exposures greater than the ADI would result from routine public exposure following ingestion of a leafy vegetable that has been directly sprayed, a quail from a sprayed area, and from a total of all routine public exposures considered (via dermal, inhalation, vegetable, water and highest meat).

The EIS assumes "[b]ecause of the safety factor and the fact that this level of exposure would be present only for limited periods--not every day--it would seem reasonable that an estimated dose could exceed the ADI by a small amount without causing harm." (p. 4-23) Nowhere is there any evidence that doses above an ADI should be considered safe. No standard toxicology book concludes such a thing. Without documentation for this absurd theory, the statement should be withdrawn and the risk restated.

5-20 The EIS continues with the following:

With regard to the NOEL's, it is important to note that for all three chemicals these were the highest doses tested that caused no observed effect, and the effects observed at the higher doses were <u>not</u> lethal. So a dose that exceeds the

NOEL might not be as harmful as one might initially conclude. (p. 4-23)

5-20 This statement is infuriating and lacks scientific integrity. A NOEL is determined from either chronic or sub-chronic toxicity tests. The highest dose tested for which there is no observed effect is assigned as the NOEL. Of course, doses above that threshold will cause damage (i.e., an effect). What is this garbage about effects at a higher dose not being lethal? These tests are not designed to cause mortality. A DOSE ABOVE A NOEL HAS CAUSED DAMAGE IN THE TEST ANIMAL AND MUST BE CONSIDERED HARMFUL.

NOELs are derived from animal tests and are not, in themselves, an acceptable standard for human safety. Standard toxicological practice is to assume safety factors when extrapolating animal testing data to human populations.[3] A 10 fold safety factor is assigned when extrapolating from animal data to humans. An additional 10 fold safety factor accounts for the normal variation in human populations. Frequently, additional safety factors are imposed when sensitive populations are considered or when the original animal testing data are deficient.

5-21 ADIs are determined by EPA and are also extrapolated from animal data. When an ADI is exceeded, APHIS should be concerned about the exposure levels to which humans are being potentially subject. In the case of malathion, the ADI was set by EPA using only a factor of 10 below the lowest animal NOEL. As exposure rates reach or exceed the NOELs, APHIS had better be very clear about the risks that their programs pose. The flippant minimizing of risks in the DEIS is inappropriate and unacceptable.

Despite APHIS' claims that the assessment is overly conservative, the analysis and judgments made in Chapter 4 are sc grossly out of line with accepted public safety standards that the conclusions are wrong. APHIS must redo this section and present risks in an accountable manner.

5-22 The EIS considers only the insecticides' active ingredient to reach conclusions of safety. No analyses are given for the full formulations of the insecticides. All other ingredients (the secret, or inert, ingredients) that will be sprayed over vast acreages by APHIS are not even mentioned or evaluated. These secret ingredients are not biologically inert. The EPA has registered 1200 "inert" ingredients for use in pesticides. The EPA indicates that they know virtually nothing about the toxicity of approximately 800 of the ingredients, know 55 "have been shown to be carcinogens, developmental toxicants, neurotoxins, etc.," know that the chemical structures of an additional 51 ingredients are suggestive of these same problems,[4] and are "concerned about petroleum distillates which occur in about 80% of all pesticide formulations...and pose significant regulatory problems."[5]

5-22 Without consideration of the secret pesticide ingredients that will be sprayed over millions of acres, the EIS lacks scientific integrity. APHIS must assess the impacts of spraying these secret ingredients and discuss them in a Supplement.

5-23 IPM has access to all methods of grasshopper control, but chooses those techniques that are least disruptive of the environment and pose the least harm to human health. APHIS must include specific changes in the final EIS that assure the public that the methods chosen for grasshopper programs are effectively preventing grasshopper outbreaks while establishing long-range control.

(5) Evaluation of the effects of the grasshopper control program must be expanded.

5-24 The Draft EIS limits monitoring for the effects of grasshopper control programs to vegetation samples and samples of flowing or impounded water in or adjacent to the area designated for grasshopper spray programs. (p. 1-13) It also mentions monitoring in sensitive areas associated with threatened or endangered species and proposes further research for effects on endangered and migratory birds. (p. 1-14)

The EIS exempts biological control agents from monitoring because *Nosema locustae* is very target-specific and "produces no known off-site impacts". This is not acceptable.

Knowledge from evaluation of the effects of a program is a crucial link in the chain of information required to accomplish an effective program with a systems approach. This monitoring will constantly add understanding to what we know about the effects agency actions have on the ecosystem.

5-25 In 1986, the Oregon Department of Agriculture's gypsy moth program sprayed 200,000 acres with a biological agent, *Bacillus thurengiensus* or *B.t.* Money was allocated from the state budget to conduct three evaluation projects to determine the effects of *B.t.* on non-target caterpillars,[6] pheasant egg hatch,[7] and the reproductive success of chickadee birds.[8] The populations of non-target caterpillars were significantly reduced for eight weeks after treatment. This is a longer period of time than expected, considering *B.t.*'s expected persistence and efficacy. Incubated pheasant eggs treated with *B.t.* had a reduced hatch, although chickadee nests (a cavity nester) inside and outside the spray zones were equally as successful at rearing young. Biological agents cannot be exempt from evaluation for the program's effects on the ecosystem just because adverse effects are unknown.

5-26

Finally, the DEIS is deficient in ensuring meaningful public participation in the decisionmaking process. Ranchers and landowners are the only public assured of notification and participation in planning and developing the site-specific projects. NEPA requires wider public agency and public citizen participation than the proposal put forth in the DEIS. Changes must be made in the EIS to ensure greater public participation in reviewing and evaluating monitoring data, determining the need for action, designating treatment boundaries, selecting treatment methods, and considering mitigation measures as needed.

Conclusion

5-27

APHIS must seriously rethink these deficiencies in the preferred alternative to ensure the following:

1) The most effective program will be conducted that emphasizes prevention and ensures long-term control for grasshoppers.
2) The preferred alternative reflects a systems approach to grasshopper management and incorporates the five step decisionmaking process developed in classical IPM.
3) The need for treatment is clearly documented.
4) Alternatives to pesticides are considered first before resorting to chemical insecticide treatements.
5) Health risks are reanalyzed using accepted public health standards.
6) Secret (inert) pesticide ingredients are analyzed for impacts and risk.
7) Public participation opportunities are expanded.

The deficiencies with the DEIS are basic and new information will need to be developed in order to comply with NEPA. The only prudent manner to proceed is to issue a Supplement that corrects the presentation of the preferred alternative to meet the stated goals of the APHIS program, properly assesses human and environmental health risks, and encourages public participation in grasshopper management programs.

NCAP appreciates this opportunity to comment on the Draft. We look forward to receiving a copy of further documents that are developed for APHIS's grasshopper management programs.

Sincerely yours,

Norma Grier

Norma Grier
Director, NCAP

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6

Sunrise, Mt. McKinley   Ansel Adams

SIERRA CLUB LEGAL DEFENSE FUND, INC.

1600 Broadway Street, Suite 1600   Denver, Colorado 80202   (303) 863-9898

ROCKY MOUNTAIN OFFICE

Lori Potter
H. Anthony Ruckel
Karin P. Sheldon
Staff Attorneys

Douglas L. Honnold
Law Associate

Other Offices

SAN FRANCISCO OFFICE

2044 Fillmore Street
San Francisco, CA 94115
(415) 567-6100

WASHINGTON, D.C. OFFICE

1516 P Street, N.W.
Suite 300
Washington, DC 20005
(202) 667-4500

ALASKA OFFICE

419 6th St.
Suite 321
Juneau, AK 99801
(907) 586-2751

December 16, 1986

Charles Bare
Staff Officer
PPQ-APHIS-USDA
Federal Building, Rm. 663
Hyattsville, Maryland 20782

Dear Mr. Bare:

The following comments on the Draft Environmental Impact Statement for the Rangeland Grasshopper Cooperative Management Program (DEIS) are submitted on behalf of the Sierra Club Legal Defense Fund and its client, the Sierra Club.

The DEIS, while in organization and readability an improvement on the 1986 Programmatic EIS (PEIS), suffers from many of the same substantive deficiencies which severely flawed that earlier attempt at environmental analysis. APHIS will need to face these problems squarely and make fundamental changes in the EIS if the final version is to satisfy NEPA.

Like the earlier PEIS, the current DEIS is characterized throughout by a deliberate evasion of the serious environmental issues surrounding APHIS's grasshopper program -- issues which have been brought repeatedly to the agency's attention.

6-1

As in the past, APHIS has described its chemical pesticide spray program as "integrated pest management," without adopting in any concrete manner the preventive and ecological principles properly denoted by that phrase. Detailed analysis of important preventive alternatives is arbitrarily deferred, pending unspecified study by an inter-agency work group (a group having at present neither

a budget, see DEIS at 2-18, nor a research work plan, Charles Bare, personal communication, 11/19/86). The use of Nosema locustae, a biological control agent of acknowledged efficacy and no adverse impacts, is discussed in only a vague and general way, as one method which might be employed, at the unguided discretion of local APHIS personnel and cooperators. The DEIS provides neither a target acreage for use of Nosema in upcoming years, nor a decision framework to guide local decision-makers in their determination of whether to use Nosema. To exacerbate the problem, the DEIS authors propose no changes in the provisions for public participation in local decision-making, an aspect of the program which has proven woefully inadequate, and which has contributed to the hasty and ill-considered decisions made at the local level.

6-1

The preferred alternative is thus a prescription for continuation of the program's past operation, in which Nosema has been given serious consideration at neither the programmatic nor the site-specific level, in which the actual decisions in site-specific projects have been made with little or no analysis of alternatives and their impacts, and in which "public" participation has been effectively restricted to meetings with the ranchers whose land is to be sprayed. The DEIS is a prescription for continuation of APHIS' reliance on crisis-response to the exclusion of prevention, and overwhelming reliance on chemical pesticides as the method of response.

I. Description of the Preferred Alternative ("IPM")

In the DEIS, APHIS has for the first time recognized that the goals of a true Integrated Pest Management program are to prevent, rather than suppress, severe economic infestations, and to minimize the use of chemical pesticides, DEIS at xvi, 2-18.

6-2

Unfortunately the "IPM" program described in the DEIS does not live up to that promise. Methods for the preventive control of grasshopper populations are not seriously discussed, but are instead arbitrarily deferred to some indefinite, and perhaps mythical, future. DEIS at xvii, 2-18 to 2-25. The use of Nosema locustae, the only non-chemical method acknowledged by the DEIS authors as "currently available", DEIS at 2-16 to 2-18, is discussed in only the vaguest and most general of terms. No target acreages are set for the use of non-chemical methods, nor are local APHIS staff directed to use non-chemical methods wherever feasible. Indeed, the DEIS provides no definite

or concrete guidance at all in the choice between chemical pesticides and less damaging methods such as Nosema. In light of APHIS' historical bias toward the reactive use of chemical pesticides, DEIS at xiii, xvi, 1-12, the failure to mandate the use of Nosema in specified circumstances is a certain recipe for the continuation of overwhelming reliance on malathion, carbaryl, and acephate. As in the past, the DEIS authors have paid only token homage to IPM. Behind this facade may well continue unabated the wholesale poisoning of our rangeland environment.

6-2 In the final EIS, APHIS should describe in much more detail the composition, objectives and operation of the interagency IPM work group. What funds are available to the group? What are its research plans? In particular, will the group research preventive methods such as grazing management, or will it only work to refine the use of insecticides? What will be the staffing of the work group? It should include at least one full-time IPM specialist.

The DEIS authors note that new control and prevention methods will not be used until they have been "adequately tested ... and approved by the IPM work group ..." DEIS at 2-18. What criteria will be used to determine whether the methods are ready for field use? Will the work group's research results, and its decisions on what methods to "approve", be available to the public for information and comment? The final EIS must answer these and similar questions about the IPM Work Group.

II. Rejected Alternatives for Prevention and Control, and Economics of the APHIS Program.

6-3 In our scoping comments (attached and incorporated as Exhibit A) we urged that preventive methods, particularly the reduction of livestock grazing pressure, the diversification of rangeland vegetation, and use of Nosema prior to a severe outbreak, should be a primary focus of the 1987 programmatic EIS. In those comments, we noted that prevention of outbreaks is within APHIS's statutory authority, that detailed consideration of preventive methods is essential to a reasoned choice among alternatives, and that the preventive methods proposed are neither remote nor speculative in their application. Exhibit A at 1-3.

Without refuting (or even discussing) these points, the DEIS authors have largely avoided giving

serious consideration to preventive alternatives.

The DEIS authors, reviewing studies on grazing and grasshopper populations, conclude:

> It is generally accepted that overgrazing opens up the plant canopy and improves the microhabitat for important pest species of grasshoppers through decreased relative humidity, increased temperature, and increased solar radiation.[1]

DEIS at 2-22.

Similarly, a researcher in grasshopper populations found:

> Most studies have found that heavily grazed or otherwise disturbed areas have wider fluctuations in densities, a smaller number and different array of species, and higher overall densities than lightly grazed or undisturbed areas.

6-3 Jepson, scoping letter (attached as Exhibit B), at 3 (citations omitted). In the 1986 FEIS, APHIS reached much the same conclusions:

> The tendency of grasshopper populations in monocultures to oscillate widely in "boom-and-bust" cycles is well known and is in strong contrast to the characteristically more stable grasshopper populations associated with abundant, complex plant communities.

1986 DEIS at 7-8.

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1 As the DEIS authors note, the results of one study, Capinera and Sechrist (1982), suggest that grasshopper population response to grazing may vary somewhat with varieties of host plant, grasshopper species, and intensity of grazing. The DEIS authors make no attempt, however, to delineate the types or extent of variation. The detailed discussion required by NEPA involves determining under which conditions grasshopper populations can be controlled with reduction of grazing pressure, and how what might be accomplished. Instead the DEIS authors conclude, from the evidence of variation, that "no single prescription" will work in all circumstances. This unsurprising conclusion provides no basis on which to dismiss range management from detailed consideration.

6-3 Despite this scientific consensus, the DEIS authors dismiss grazing management and range diversification as control methods without the detailed analysis which NEPA requires. Grazing management is not presented in comparative format as an alternative to pesticides, as required by NEPA's implementing regulations, 40 C.F.R. § 1502.14. It is not "rigorously explore[d] and objectively evaluated[d]", 40 C.F.R. § 1502.14(a); nor is any mitigation that might be necessary discussed, § 1502.14(f). Most important, the authors do not discuss at all the environmental effects of grazing management methods (including their direct, indirect, and cumulative effects), any unavoidable adverse impacts, or the relationship of grazing management to the long-term productivity of the range. 40 C.F.F. § 1502.16. Diversification of rangeland vegetation is not discussed at all.

The DEIS authors do indicate that research on grazing intensity "may" be undertaken by the IPM Work Group. DEIS at 2-23. Even if plans for such research were definite, however, they would be no substitute for inclusion of detailed analysis in the EIS. NEPA requires detailed analysis and comparison of all reasonable alternatives <u>before</u> a decision is made, and is not satisfied by the mere possibility that such information will be developed later.

6-4 With regard to the use of <u>Nosema</u> as a preventive measure, the DEIS is still more deficient. The DEIS authors themselves conclude that "<u>Nosema</u> is most effective if introduced in the early stages of an <u>infestation or when an infestation is predicted to occur</u>." DEIS at 2-17 <u>(emphasis added)</u>. Yet <u>nowhere in the DEIS</u> is this use of <u>Nosema</u> discussed or compared to other control methods. Instead, <u>APHIS</u> remains firmly tied to reactive, crisis-oriented strategies, under which control is initiated only when infestations reach levels intolerable to ranchers and land managers.

6-5 The DEIS authors dismiss another promising control method, a mixed carbaryl/<u>Nosema</u> bait, in one paragraph. DEIS at 2-20. The reason given <u>is</u> that such a mixture is not yet registered by EPA. <u>Id</u>. Such cursory dismissal of this reasonable alternative <u>is</u> completely unwarranted. First, as a legal proposition it is arguable whether separate registration would be required for the combined use (each at a lower than usual dose) of two registered pesticides, especially where one (<u>Nosema</u>) is not known to have any adverse impacts on non-target <u>organisms</u>. <u>See</u> 7 U.S.C. § 136(ee) (users are not prohibited from applying pesticides at lower doses or in different manners than specified on label, or from mixing pesticides with fertilizers, unless label specifically prohibits). Second, APHIS could itself seek registration for use of a mixed bait.

6-5 <u>See McGill v. EPA</u>, 593 F.2d 631, 637 (5th Cir. 1979) (users as <u>well</u> as manufacturers may register products). Under § 136a(c)(7)(A)(i) EPA may conditionally amend a registration to allow a new use which would not significantly increase environmental risks. Certainly there is no evidence, and no reason to suppose, that combined application of carbaryl and <u>Nosema</u> would have greater risks than the use of carbaryl alone. <u>Alternatively</u>, APHIS could seek local needs registration from one or more states. 7 U.S.C. § 136v. In either case, the agency could register the mixed use without having to submit or verify previously collected data on the impacts of the components. 7 U.S.C. § 136a(2)(D).

The proposal for a mixed carbaryl/<u>Nosema</u> bait is not a new one. It was brought to the agency's attention in comments on the 1986 PEIS; APHIS dismissed it there for the same reason as in the current DEIS. NEPA requires that, in place of such arbitrary neglect of a reasonable alternative, the agency give it serious and detailed consideration.

6-6 One of the strongest complaints against the 1986 EIS was that it failed uttlerly to account for the long-term economic and biological impact of livestock grazing on western rangelands in relation to range insect conditions. The new DEIS does not correct that failure.

Livestock grazing of public lands had been widely condemned as a major cause of rangeland erosion and herbage conditions that favor grasshopper epidemics. It has also been condemned as a public subsidy of a small minority of livestock operators who pay insignificant fees to graze on 323 million acres of public lands (about 43% of the total land base in the eleven western states) and produce an insignificant 2% of the nation's red meat supply. Lynn Jacogs, <u>Free Our Public Lands</u> (1968); Denzel and Nancy Ferguson, <u>Sacred Cows at the Public Trough</u> (1983).

In most areas of the west, cattle and sheep are more serious invaders of the range than grasshoppers, and their impact on the land exacerbates the impact of grasshoppers. Grasshoppers are, after all, a natural component of rangelands and have been for several millenia. They do not present a threat to the long-term productivity of the rangeland resource. They are, in fact, part of that resource and contribute to its long-term health as part of the consumer-producer cycle. It is a major failing of the DEIS that is does not thoroughly analyze the economics of its grasshopper program in relation to livestock grazing.

6-7 One preventive measure that should be implemented immediately is a limiting of federal funds for grasshopper spray projects to those areas where range condition is rated at satisfactory or better. APHIS should require that effective range mange improvement practices be in place on all cooperators' rangeland (private, state and federal) that is in poor or very poor condition.

III. <u>Choice of Treatment Methods</u>

A fundamental flaw in the DEIS is that the authors provide no concrete framework for deciding what control method to use in a given instance. Without such a decision framework, it is impossible for either the public or decision makers to evaluate the environmental impacts of the preferred ("IPM") alternative.

The DEIS authors state repeatedly that the IPM alternative is less damaging than the exclusive use of chemical pesticide sprays, since impacts will be reduced by the use of <u>Nosema</u> and carbaryl bait in some projects. <u>See</u>, <u>e.g.</u>, DEIS at <u>4-7</u> (impacts on soils), 4-40 (wildlife), 4-66 (human health). Yet nowhere do the authors prescribe the situations in which <u>Nosema</u> will be used. No target acreage is set, nor is any <u>preference</u> established for the use of <u>Nosema</u> wherever possible. The proposed "IPM" alternative is so <u>vague</u> and general as to evade intelligent evaluation entirely. This "programmatic" DEIS proposes no concrete program, but merely describes the agency's repertoire of pesticides, with no effort to define the conditions under which each would be used.

6-8

We made the same criticism of the 1986 PEIS, urging in our scoping letter that in the new PEIS the agency provide a proposed decision framework for the choice of whether to treat an infestation and what method to use. Two possible frameworks were suggested as illustration. Appendix A at pp. 3-5. Nevertheless the DEIS authors have neither proposed a decision framework nor explained their decision not to do so.

On the programmatic level, APHIS's NEPA documentation has been, and in the DEIS continues to be, insufficiently definite to allow informed decision-making or public participation. On the local, site-specific level, the grasshopper program NEPA documentation has been hastily prepared, has failed to provide for public participation and comment, and has relied on the general analysis of the DEIS, with no real site-specific supplementation. Thus the lack of a decision framework at the programmatic level has resulted in a

complete evasion of the comparison of alternatives required under NEPA.

While it might be theoretically possible for all of the needed comparison of alternatives and their impacts to be made in site-specific NEPA documentation, the historical tendency has been just the opposite: EAs done for specific projects have either not considered alternative control methods at all or have considered only chemical pesticides. This has been the case whether the EA was prepared by APHIS or by its cooperators, USFS and BLM.

In many EAs the only alternatives considered have been "no action" and use of a chemical pesticide. <u>See</u>, <u>e.g.</u>, Environmental Assessment On The 1986 Eastern Oregon <u>APHIS</u> Rangeland Grasshopper Cooperative Management Program On BLM-Administered Lands (attached as Exhibit C), at 3; Decision Notice/Environmental Assessment/Finding Of No Significant Impact for the Fillmore Ranger District, Fishlake National Forest, 1986 (attached as Exhibit D) at 1.

6-8 In other cases, the agency involved simply did not discuss alternatives to the proposed action at all. <u>See</u>, <u>e.g.</u>, Finding Of No Significant Impact, Spanish Fork Ranger <u>District</u>, Uinta National Forest, Utah, 1986 (Exhibit E) at 1.

Perhaps the most common approach has been simply to note that Integrated Pest Management was chosen as the preferred alternative in the PEIS, and then state, without further explanation, that a given chemical pesticide will be used in this particular project. <u>See</u>, <u>e.g.</u>, Environmental Assessment, 1986 Cooperative Grasshopper <u>Management</u> Program For Detailed Work Plan Number DWP-15-614-86-OR, Wallowa County, Oregon, 1986 (Exhibit F) at 2; Environmental Assessment, 1986 Cooperative Grasshopper Management Program For Detailed Work Plan Number NM-1-86 (Exhibit G) at 1; Environmental Assessment, 1986 Cooperative Grasshopper Management Program For Detailed Work Plan Number DWP-1-GC-86-AZ (Exhibit H) at 2.

In these and other instances, APHIS and cooperators have claimed to be "tiering" the EAs to the PEIS. But where the PEIS provides no concrete guide to selection of treatment sites and methods, the EAs cannot be legitimately tiered to such a (non-existent) analysis. <u>cf. Earth First v. Block</u>, 569 F.Supp. 415, 419 (D. Oregon 1983) <u>(site-specific EIS cannot</u> be tiered to deficient programmatic EIS). APHIS has been playing a "shell game." In the PEIS, the agency defers analysis of alternatives to the site-specific EA; in the EA, APHIS claims it has been done in the PEIS.

6-9

IV. Public Participation In Selecting Treatment Sites And Methods

The proposed grasshopper control program, like past APHIS grasshopper programs, is deficient in failing to provide for meaningful public participation in the decision process.

The DEIS authors note that "[i]n planning a cooperative treatment, APHIS meets with the requesting agency or landowner to discuss the control options available ..." DEIS at 1-12. When APHIS has made its predictions of infestation areas, only "land managers and ranchers" are informed of the findings. DEIS at 1-10.

In addition to meeting with ranchers and land managers, APHIS should inform and meet with interested members of the public and state fish and wildlife agencies as soon as APHIS begins to plan for treatment in a given area. In the past, APHIS has failed to inform interested members of the public and responsible state agencies until shortly before treatment was scheduled to begin, and planning was essentially complete.

In APHIS' 1986 spray program in Graham and Cochise Counties, Arizona, for example, the agency did not provide an environmental assessment until four days before the scheduled spraying. See letter from the Arizona Center for Law in the Public Interest to APHIS, 5/30/86 (Exhibit I). At the last minute, APHIS enlarged the proposed spray area, without notifying the interested public or state agencies responsible for monitoring impacts on wildlife. See letter from the Arizona Game and Fish Department to APHIS, 5/6/86 (Exhibit J).

As discussed above, environmental assessments created by APHIS and cooperators have typically been hastily prepared, cursory documents clearly intended to justify, rather than analyze, a proposed spray program. In particular, discussion of alternatives to chemical pesticides has often been totally neglected. Improved public participation, at all stages of the decision process, would help the agency to comply with NEPA.

First, APHIS's predictions of likely infestation levels (made in winter, see DEIS at 1-7 to 1-10) should be shared not only with ranchers and federal land managers but with interested members of the public and state agencies. The public distribution list should include, at a minimum, all those in a given state who have requested notice of spray programs or who have commented on APHIS programs and NEPA documents. Second, the same group should be immediately informed of the proposed treatment boundaries established by APHIS's delineating surveys,

6-9

see DEIS at 1-10, and should have full opportunity to participate in the meetings at which a control method is selected. DEIS at 1-12. Finally, the resulting EIS or EA, which must discuss in detail the site-specific impacts and effectiveness of each alternative considered, should be circulated in draft form for public comment.[2] At least 45 days must be allowed for public comment, 40 C.F.R. § 1506.10, and no action may be taken until 30 days after release of the final document. Id. Because the agency has chosen to defer all meaningful comparison of alternative control methods to the site-specific document stage (see Part III of this letter), these circulation and time period requirements apply whether the document prepared is an EA or an EIS. See Save Our Ecosystems v. Clark, 747 F.2d 1240, 1247 (9th Cir. 1984).

We urge that all of the above changes in APHIS' decision-making process be incorporated into the preferred alternative in the final EIS. Informed public comment and participation is, of course, essential to the NEPA process. The current program, perpetuated in the DEIS, has locked out the public, screening real decision-making from public scrutiny and severely limiting the facts and points of view to which decision-makers are exposed.

V. Wildlife Risk Assessment

The estimation of wildlife risks is an improvement over that in the 1986 PEIS. It still suffers, however, from questionable methodology, unsupported conclusions, and the lack of a prescribed framework for site-specific wildlife risk analysis.

6-10

The DEIS authors have relied for their wildlife risk assessment on the standards established by the EPA in that agency's handbook, Ecological Risk Assessment (1986). See DEIS at 4-21. In particular the authors adopt EPA's criterion for Significant Risk: a significant risk is posed (to non-endangered species) if the estimated environmental concentration (EEC) exceeds one-fifth of the 50% lethal dose (LD_{50}).

See 6-8

2 In Part III of this letter we have urged that the final programmatic EIS include a concrete decision framework by which the selection of a control method will be made. This would enable APHIS to fulfill its remaining NEPA obligations at the site-specific level within a realistic time period.

6-10

However, the DEIS authors in fact compare the LD_{50} to an estimated actual dose, rather than to an EEC. This difference in methodology is potentially significant because the EEC will normally be larger than the average dose, since the animal will not take in to its body all contaminants in its environment. By using the EPA's one-fifth criterion, then, the DEIS authors may be underestimating risks. The authors need to reexamine their adaptation of EPA's methodology and, at the least, justify it to the EIS reader.

Under the system used by EPA, it is assumed that terrestial animals may limit their dose by moving out of treated areas or switching to alternate food items. Ecological Risk Assessment at 5. Thus the average dose is assumed to be lower than the EEC. The EEC's used by EPA are estimated "concentrations in important media of concern (i.e., water, soil, non-targeted organism food items)." Ecological Risk Assessment at 8. The usual means of comparison is to convert an experimental LD_{50} into an LC_{50} in the environment, and to compare that converted LC_{50} directly with an EEC. Ecological Risk Assessment at 34, 37 (Table 8), 38. It is in this comparison that the one-fifth criterion is used.

In the DEIS method, on the other hand, an one-day dose is estimated and compared to an experimentally-derived LD_{50}. While this may be an equally good method, there is no reason to think, a priori, that the same one-fifth criterion can be used. Since the authors are using this criterion in a way very different from its use in the EPA method, they should explain how it was chosen and why it is appropriate or meaningful.[3]

6-11

A second important flaw in the analysis of wildlife risk is that the risks revealed by the literature review and quantitative analysis are ignored or understated in conclusory statements elsewhere in the DEIS. The DEIS authors provide no support for the statements (prominently placed in the summary section of the DEIS) that "there have been no significant impacts on wildlife in areas treated with chemicals at application rates similar to those proposed..." and that "none of the chemicals would adversely affect wildlife populations." DEIS at xxi.

6-12

[3] There is also a confusing typographical error in Table 4-2, which should be corrected. This table is taken from Table 1 in Ecological Risk Assessment. The EPA criterion for unacceptable risk to endangered mammalian species is EEC greater than or equal to one-tenth LC_{50}, not 1.10 LC_{50}.

6-11

Instead, the hazard and risk analyses show, in the DEIS authors' own words, that "[t]o the extent that grasshopper spraying causes a severe reduction in target and nontarget insects, it is likely to jeopardize the survival of local populations of these wildlife species." DEIS at 4-31, 4-32. By the authors' calculations, estimated doses of malathion and carbaryl exceed EPA risk criteria for a number of avian and mammalian species. DEIS at 4-34 to 4-35. The authors found that "[i]t is not possible to accurately predict the degree of ChE [cholinesterase] inhibition likely to occur in birds or the subsequent effects on the birds' behavior from a given grasshopper control application of carbaryl..." and that "carbaryl may cause a significant reduction in the reproductive success of some avian species..." DEIS at 4-25.

From this and other information in the hazard and risk analysis, an objective reader could only conclude that the use of chemical pesticides poses serious, and in some cases unknown, risks to local wildlife populations. The conclusory statements to the contrary should be deleted and replaced with conclusions that accurately reflect the data.

6-13

A third major deficiency is the failure to prescribe a framework for wildlife risk analysis on the site-specific level. The DEIS data show wide variation in the degree of risk to which wildlife species are subject. At particular risk are those species relying on insects as a primary food source, those which would be unable to find alternate food sources, those whose mating and nesting cycles correspond with spray periods, and in general small mammals and birds, who are more severely affected by the pesticides. When carbaryl bait is used those birds and mammals which will eat the bait in quantity are at greater risk. DEIS at 4-30 to 4-37. At the site-specific level, the NEPA document should identify these (and any other) high-risk wildlife groups present in the area and estimate the short and long term effects on populations of these species.

In the past, this site-specific analysis has generally not been done. Instead, the EAs prepared have merely echoed the general optimistic conclusions of the PEIS. See, e.g., Environmental Assessment, Mormon Cricket Control Project, Fillmore Ranger District, Fishlake National Forest, 1986 (Exhibit D), at 2. As with the consideration of alternative control methods (see Part III of this letter), the needed detailed analysis is being done neither at the programmatic nor the site-specific level. By specifying in the PEIS the aspects of wildlife risk to be analyzed site-specifically, APHIS would begin to remedy this situation.

VI. **Buffer Zones Around Streams, Lakes, and Raptor Nest Sites.**

6-14

The DEIS authors propose to leave only 200-500 foot buffers around bodies of water and one mile buffers around peregrine falcon and bald eagle eyries. DEIS at 2-27 to 2-30.

The U.S. Fish and Wildlife Service (Rocky Mountain Office) has concluded that a 1-mile buffer is inadequate around peregrine eyries. Instead, the USFWS required a buffer zone of at least 10 miles. A large buffer is needed because of the falcon's wide foraging area (up to 17 miles). Biological Opinion For The 1986 Grasshopper Control Program In Utah, July 3, 1986, at 7, 25. APHIS' operational procedures should be revised to comply with the conclusions of USFWS.

USFWS also concluded that in some situations 500 foot buffers were inadequate to protect streams and lakes from spray drift and runoff, and that buffers of 1/4 mile were needed. Biological Opinion at 17, 21, 24. APHIS should revise the EIS to reflect the need for larger buffers around streams and lakes.

With regard to effects on endangered species in the Rocky Mountain states, APHIS should consult with the Rocky Mountain Office of USFWS, rather than the national office. The Rocky Mountain Office's past activities in assessing APHIS's program have given it the familiarily and expertise to best determine the threats to endangered species and the necessary mitigation measures.

VII. <u>Conclusion</u>

6-15

As noted, many of the criticisms and suggestions made above should not be new to the agency. They have been voiced in comments on previous NEPA documents, in scoping letters, and in protests and appeals of local agency projects. It is time that APHIS ceased attempting to evade its NEPA responsibilities, and began addressing in good faith the alternatives to the agency's established program, the need for better decisionmaking at the site-specific level, and the serious impacts of chemical pesticides on local wildlife. We hope that these comments will be helpful in accomplishing that vital task.

Very truly yours,

Jason Marks, Law Clerk
Douglas L. Honnold, Esq.
Rocky Mountain Office

0307m

7

Huachuca Audubon Society
Post Office Box 63
Sierra Vista, AZ 85636

December 13, 1986

Mr. Charles H. Bare, Staff Officer
PPQ-APHIS-USDA
Federal Building
Room 663
Hyattsville, MD 20782

Dear Mr. Bare:

The Huachuca Audubon Society offers the following comments on your department's DEIS on the Rangeland Grasshopper Cooperative Management Program.

7-1

<u>Overview of the Situation</u>- APHIS has a notoriously bad track record in the past for treating grasshopper control one dimensionally. There are very few examples of using anything but toxic sprays for abatement. This new DEIS needs to set a precedence by seriously considering other alternatives in control. APHIS has also in many instances acted with a crisis management philosopy with little long term planning. Such midnite hour approaches have led the Huachuca Audubon Society to question whether APHIS adheres to the spirit of the National Environmental Policy Act the same as other federal agencies.

7-2

<u>Integrated Pest Management</u>- This treatment must be seriously considered by APHIS. This control approach, where appropriate, offers a long term solution. Use of sprays alone does not! Specific area proposals still need close coordination with other affected agencies. Public involvement is an important part of that coordination. Also APHIS should provide adequate time for agency and public response to local treatment proposals. Last year's Cochise County spraying program is a good example of public and other agency involvement being poorly handled.

7-3

As you know biological control is an important part of integrated pest management. <u>Nosema locustae</u> currently offers good results if used. But again, planning must be multi-year for this parasite to be effective.

7-4

Cultural practices at the infested site must be considered before treatment begins. For rangeland, grasshopper treatment will not greatly increase the pounds of forage on an already overgrazed pasture. Many times, in fact, grasshoppers thrive on over used ranges. Proper forage use levels on forage must be met before using public money on private, state or federal lands.

7-5 General- A step down chart of implementation of a control proposal needs to be part of this DEIS. In other words, who does what and when in a local treatment project. And APHIS should not be the lead agency in initiating action. The affected land manager should fill that role. More credence will be put in your agency's activities if such a planned and ppen committment is made.

Thanks for this opportunity to comment. We look forward to better conservation practices from APHIS in the future.

Sincerely,

Tom Collazo

Tom Collazo, President
Huachuca Audubon Society

8

THE STATE OF WYOMING

ED HERSCHLER
GOVERNOR

Game and Fish Department

BILL MORRIS
DIRECTOR

December 17, 1986

EIS 436/L2
USDA/Animal & Plant Health Inspection Service (APHIS)
DEIS 1987-Rangeland Grasshopper Cooperative Management Program

Mr. Charles H. Bare
Staff Officer
PPQ-APHIS-USDA
Federal Bldg. Rm. 663
Hyattsville, MD 20782

Dear Mr. Bare:

We have reviewed this draft document regarding the Rangeland Grasshopper Cooperative Management Program, and offer the following comments for your consideration.

8-1 It is our understanding that grasshopper populations tend to oscillate widely in vegetative monocultures, in strong contrast to the characteristically more stable grasshopper populations associated with abundant and complex plant communities (Campbell et al. 1974, Nerney 1958, and Weese 1939) therefore, we recommend a portion of the program efforts should be exerted to inform the public and users about the consequences of poor condition rangeland and how grasshoppers proliferate on such lands. Viewing this as a long term approach, we think it has definite potential in lieu of the short term "band-aid" approach of chemically spraying grasshoppers annually. Holistic range management advocates believe that chemical control under proper holistic management is not necessary or desirable. We feel strongly that overgrazed rangeland should be an issue that is addressed and incorporated into the overall Control Program effort.

8-2 Other considerations under the preferred alternative p. xviii states that APHIS will access any impacts that grasshopper control may have on migratory birds. Preliminary studies indicate that the young of upland game birds are severely impacted by chemical control of (grasshoppers) insects. Therefore, assessment of impacts should not be limited to migratory birds but should also take into account resident non-migrating wildlife species such as upland game birds and non-game wildlife.

8-3 We feel it is a positive move to have the biological Nosema locustae integrated into the program. We also hope that cooperators are willing to invest in long-range surveying and control strategies where appropriate rather than relying solely on the traditional reactive or crisis-oriented approach. If this is done, the impact on wildlife resources and monetary expense to all concerned will be reduced in the long term.

Thank you again for the opportunity to review the EIS for this program. Please contact us if we may be of further help.

Sincerely,

Francis Petera

FRANCIS PETERA
ASSISTANT DIRECTOR
OPERATIONS

cc: Game Div.
Fish Div.
HATS Div.
SPC

RCVD. FOSS 12-23-86

Headquarters: 5400 Bishop Boulevard, Cheyenne, Wyoming 82002

9

TO: MR CHAS. H. BARE.   DEC. 18, 1986
APHIS

RCVD. [illegible] 12-22-86

FROM: JANET OCROWLEY
PO. Bx 664
PICABO, ID 83348

RE: COMMENTS, GRASSHOPPER EIS.

9-1 AS A LANDOWNER IN RURAL AREA IMMEDIATELY ADJACENT TO AREA SUBJECT TO RECURRENT GRASSHOPPER INFESTATION, AND WHO, FURTHER, EXPERIENCED UNINTENDED COLLATERAL EFFECTS FROM AERIAL SPRAYING IN 1985 MAY I THANK YOUR STAFF FOR THE EXCELLENT DOCUMENT THEY PRODUCED. IT ANSWERED A WHOLE HOST OF QUESTIONS THAT NO ONE LOCALLY HAD TIME OR EXPERTISE TO RESPOND TO.

9-2 THIS MAY BE THE BEST PLACE TO INSERT A STRONG CALL FOR PARTICIPATING AGENCIES, SUCH AS B.L.M. TO RESTUDY THEIR MANAGEMENT PLANS TO INCLUDE FACT THAT GRASSHOPPERS DO, IN FACT PREFER. OVERGRAZED RANGELAND - AND ALSO TO INCREASE THEIR VIGILANCE IN DETECTING AND PREDICTING GRASSHOPPER BUILDUPS. IT OCCURS TO ME THAT A SIGNIFICANT AMOUNT OF SPRAY TIME & MONEY WAS SPENT IN 1985 PROTECTING
9-2 RANGELAND ALREADY GONE ALMOST EXCUSIVELY TO CHEAT GRASS + MUSTARD. WHY THEY DID NOT SIMPLY ENCOURAGE THE GRASSHOPPERS TO SCOUR THIS AREA CLEAN. IS BEYOND ME.

9-3 MAY I ENCOURAGE APHIS TO PURSUE ITS FOREWARD LOOKING INTEGRATED PEST CONTROL MANAGEMENT, WHILE ASKING BLM + FOREST SERVICE TO UPDATE THEIR RANGE MANAGEMENT PLANS TO INCLUDE BEST MANAGEMENT PRACTICES FOR GRASSHOPPER EPIDEMIC PREVENTION.

THANK YOU FOR YOUR KIND ATTENTION—

Janet Ocrowley.

10

THE STATE OF WYOMING

Wyoming Department of Agriculture

TELEPHONE: (307) 777-7321 CHEYENNE, WYOMING 82002-0100

JOHN ORTON, COMMISSIONER

ED HERSCHLER
GOVERNOR

December 9, 1986

Charles H. Bare
Staff Officer
PPQ, APHIS, USDA
Federal Building, Room 663
Hyattsville, Maryland 20782

Dear Mr. Bare:

We have reviewed the Draft Environmental Impact Statement - 1987 for the Rangeland Grasshopper Cooperative Management Program and would like to offer the following comments.

10-1 First, as stated in the summary (pg xi) last paragraph and repeated in Chapter 1 (pg 1-15) 1st paragraph, site specific assessment responsibilities are mentioned. However, in neither place is state land or state cooperator responsibilities outlined. If a state cooperator is to assume that they have this responsibility, which was, by the way, dictated in the 1986 cooperative agreements, then these responsibilities should be stated in the EIS so as to maintain consistency with cooperative agreements. If by chance this change is not made to the EIS, then a question would arise as to which document takes precedence as to assessment responsibilities, the EIS or the cooperative agreements between states and APHIS.

10-2 Another area of concern to us has to do with the operational and mitigation procedures found in Table 2-1 and 2-2 (pgs 2-27 thru 2-31). More than once, buffer zones around bodies of water are mentioned. It is our opinion that these particular procedures required in the EIS are superfluous since the labels of the chemical products we use in our control programs already state what restrictions and precautions are necessary when using the products around bodies of water. Quite simply the labels state that these products are not to be applied to water period! For the EIS to mandate additional restrictions (e.g. buffer zones) exceeds what is called for by EPA and the federal pesticide law (FIFRA) which has regulatory authority over chemical usage. If label directions are followed then the intent of the law is being met and additional restrictions are not called for.

10-3 Also, in this section, recreational facilities are mentioned. This term needs to be defined in a more specific sense or eliminated from the procedures. Again, as stated previously, the specific pesticide labels will cover this situation under the precautionary statement, therefore making additional restrictions unnecessary.

"AGRICULTURE—the backbone of Wyoming"

RCVD. FOSS 12-22-86

Charles H. Bare
December 9, 1987
Page 2

10-4 As a final comment, this also deals with the operational and mitigatio procedures. On page 2-30, #14d, protection of bees, the EIS indicates n chemical products are to be applied to any blooming crops or <u>weeds</u> eithe directly or by drift. If one was to hold true to this procedure, then an control program that may be forthcoming would not be allowed to take place Consider the fact that in a rangeland control program weeds, throughout th area will be present and will be blooming at some point during control. I conjunction with this bloom period, one could also find bees present in th area, whether they be domestic or wild bees. Since the result of these tw items going hand in hand would eliminate any control taking place, th procedure should be eliminated. Another fact to consider is that in Table 2- #14b and Table 2-2 #4, procedures are outlined so as to implement control whe bees are present. These two procedures would totally contradict th aforementioned procedure on not spraying if bees are present. Again in ou opinion #14b on page 2-30 should be eliminated and more sensible procedure should be followed.

10-5 In conclusion, we feel that if pesticide label directions are followed an consistent common sense procedures are implemented then additional restrictio in most cases will not be necessary.

Thank you for the opportunity to comment and if you have any questions, please contact this office.

Sincerely,

John Orton

John Orton, Commissioner
Wyoming Department of Agriculture

JO:JWB:jb:ea

cc: Walter H. Patch, PI Manager
Jim Bigelow, Pesticide Coordinator

11

RACHEL CARSON COUNCIL, INC.
An Association for the Integrity of the Environment
formerly Rachel Carson Trust for the Living Environment, Inc.

8940 Jones Mill Road
Chevy Chase, MD 20815
Telephone (301) 652-1877

December 19, 1986

Charles H. Bare
PPQ-APHIS-USDA
Federal Building, Room 663
Hyattsville, MD 20782

Dear Mr. Bare,

The Draft Environmental Impact Statement--1987, for the Rangeland Grasshopper Cooperative Management Program shows some improvement from the 1986 version, but in many respects we still find that the comments we made about that statement, expanded from those made in our behalf by Dr. Frederick W. Plapp in 1980, are still pertinent on most points, and we suggest that they be reviewed in relation to the present state of progress.

11-1 The gradual edging toward more genuine IPM will, we hope, continue. The additional research on Nosema lucustae and the indication that by next year production may be sufficient to permit widespread use, indeed making it the principal agent for grasshopper control in many areas, is encouraging. We had also objected to the earlier reliance on reaction to crisis situations only. By now there is at least some consideration of keeping populations down to tolerable levels consistently, giving less chance for explosive population increases calling for emergency use if the chemicals that, even judging from your statistics, have serious hazards to people and the environment.

11-2 Your assessment of the effects of the three chemicals studied at length still does not tally with our information. Malathion not harmful to plants? We have references to its damaging some, and causing chromosome damage in some cases. There are still disturbing data gaps in the information available on all three, and on the petroleum oils used with some products.

11-3 Your emphasis is still predominantly on immediate toxicity, and on such long-term effects as cancer, birth defects, mutations, and sometimes how loss of prey species can affect wildlife. Neither in your references nor the discussion do we find acknowledgement of the delayed neurotoxicity that is so generally found from even the slightest exposure to organic phosphorus products. We mentioned the work of Duffy and Burchfiel, as well as the U.S. Army studies in our previous letter. These long-lasting changes in brain wave patterns, with their disturbing behavioral results, have been found in humans, rats, and monkeys. Can we assume that they will not also affect species in rangeland?

11-4 The elaborate formulae that have devised to claim that certain exposure levels for people, extrapolated from test animals, will result in only so many cases of cancer per million, and similar slight-of-hand systems, are indeed accepted by EPA and other agencies, but cancer experts among our Directors warn against too much reliance on them. Assumptions on lifetime exposures are also suspect. We can really only say that a substance found carcinogenic will increase the risk of cancer, perhaps more in humans, than in test animals. And a human may have several cancers develop in a lifetime from the dose that causes only one in a mouse.

Sincerely, Shirley A. Briggs

Shirley A. Briggs
Executive Director

RCVD. FOSS 12-22-86

12

College of Agriculture
The University of Wyoming
TEACHING • RESEARCH • EXTENSION
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EXCELLENCE

James K. Wangberg, Head
Department of Plant Science
PO Box 3354
Laramie, WY 82071
(307) 766-3103

December 12, 1986

Mr. Charles H. Bare
PPQ-APHIS-USDA
Federal Building Room 663
Hyattsville, MD 20782

Dear Mr. Bare:

12-1 I have reviewed the draft of the Environmental Impact Statement - 1987 which is in reference to the rangeland grasshopper cooperative management program. My two major concerns are with operational procedures (1) to exclude all bodies of water from insecticidal treatment, page 2-30 item 10 and (2) to protect bees from insecticidal treatment, page 2-30 item 14d. In regard to the restriction of not applying within 500 feet of any body of water that is identified within the operation area, I believe the procedure is unnecessarily restrictive as it seems to include all water within the treatment area. Certainly you do not mean to include as "any body of water" tanks of livestock water, small ranch reservoirs constructed for livestock water and soil conservation, small ponds, and puddles after rain storms. If you did mean to include these, a range grasshopper control program would be impractical as large foci of infestation would go untreated. In fact, a program designed to cut these out would be nearly impossible to accomplish.

12-2 Restriction 14d reads like it should refer to cropland rather than rangeland. I think this item should be eliminated in its entirety from grasshopper control on rangeland. It suffices that apiarists have been warned to remove their bees temporarily from the treatment area. Item 14b seems redundant since all apiarists in the treatment area receive two notices before spray operations start.

There are a number of smaller points that I would like to suggest be revised. I will take these up by pages.

12-3 Page XVI line 41-42. What experimental evidence do you have for third or fourth instar grasshoppers accepting bran bait more than other instars and adults? In my experience 5th instars and adults take bait equally well.

12-4 Page XX line 1. Phlibostroma is misspelled.

RCVD. FOSS 12-22

12-5 Page 1-2 line 11-13. Most species of rangeland grasshoppers prefer native grasses over cultivated plants.

12-6 Page 1-3 line 6. In nature the average female probably lays approximately 20 eggs. See Scharff, D. K. 1960. Ecology of the migratory grasshopper (Melanoplus bilituratus) on Montana grasslands. University Minnesota Ph.D. thesis.

12-7 Page 1-3 line 38-41. Subsequent work refutes Dyer and Bokhari's (1976) conclusion that grasses are stimulated by grasshopper feeding.

12-8 Page 1-7. Under Adult Survey. First two sentences are incorrect. Adult surveys are done in summer, immediately after control efforts are terminated.

12-9 Page 1-10 line 9-12. Delimiting survey is done only to establish specific treatment boundaries (not to establish fact of economic infestation as stated).

12-10 Page 2-19 line 16-19. ULV malathion is effective for ca. 5 days and not just 1 to 2 days as stated. See Pfadt, R. E., J. E. Lloyd, M. Ali, and G. Sharafi. 1970. Manner of pickup of ULV malathion by grasshoppers from aerially sprayed rangeland. J. Econ. Entomol. 63:1210-1214.

12-11 Page 2-21 line 2-3. What orthopteran is endangered? Is this an unsubstantiated statement?

12-12 Page 2-33. Under Biological Methods Nosema locustae, what is meant by 0.5 lb a.i./acre? I doubt if 2 billion spores would weigh 0.5 lb.

12-13 Page 3-23 third paragraph. Wyoming Basin is an old term. I have difficulty in understanding what author includes. Basins in Wyoming are at lower altitudes than 8,000 ft., e.g., Worland in the Big Horn Basin has an altitude of 4061 ft.

12-14 Page 3-24 paragraph entitled "Vegetation." The description seems to be of the central and western Wyoming grazing land but not of the mixed grass prairie of eastern Wyoming and Montana which is the most susceptible to outbreaks of rangeland grasshoppers and where ranchers have the more serious problem with these insects. See enclosed map of J. L. Dodd for a modern view of North American grasslands.

12-15 Page 4-10 line 19-24. Experimental evidence indicates malathion is taken up by grasshoppers in their food. Little mortality is caused by contact. See two reprints enclosed by (1) Pfadt, R. E., John Lloyd, M. Ali, G. Sharafi (1970) and (2) Lloyd, Joh, R. E. Pfadt, and M. Ali (1974).

12-16 Page 4-38 line 17. Add "some," "though risks to some individual breeding pairs may be greater".

12-17 Page 4:45 last paragraph. Paragraph reads like Gammarus is a stonefly along with Pteronarcella. Gammarus is a crustacean with common name of sea scud.

12-18 Page 4-70 Fig. 4-30. I don't understand what relationship 8 square yards 16, and 32 have in regard to AUM equivalent. Something is missing with these numbers.

12-19 Page 4-71. Figure 4-3 is confusing. It needs legends and more labels.

12-20 Page 4-73 line 27. I think it is preferable to refer to the published paper of Mann et al. 1986 rather than the report which is not available to readers of the EIS. Enclosed is a copy of the publication.

12-21 Page A-12 fourth paragraph line 32-37. This paragraph starts out with a sentence describing normal nervous physiology. Second sentence then states, "Both of these toxic effects are transitory..." Something in between two sentences must have been left out.

Sincerely,

Robert E Pfadt

Robert E. Pfadt
Professor of Entomology Emeritus

REP:kds

Encl.

13

Evans BioControl, Inc.

484 Turner Drive / P.O. Box 3266 / Durango, Colorado 81302 / (303) 259-4200

December 19, 1986

Chuck Bare
Staff Officer
PPQ-APHIS-USDA
Federal Building Rm. 663
Hyattsville, MD 20782

Dear Mr. Bare,

Please find below detailed comments on the APHIS RANGELAND COOPERATIVE MANAGEMENT PROGRAM - Draft Environmental Impact Statement - 1987.

Before I get into the comments, however, I would like to make you aware of a personal correspondence regarding the use of Nosema locustae in the state of Idaho in the 1986 season which were made to me by Mr. Steve Ellis of BLM office in Boise.

13-1 Nosema locustae was used on approximately 17,600 acres in Idaho in the 1986 season. I am enclosing some data presented by Dr. Larry Sandval from the University of Idaho who did counts in the Nosema treatment areas which showed a reduction in population from June 27th through Sept. 8th of approximately 97%. Dr. Sandval did not want to speculate at the time he presented this data on the effect of Nosema on population until the lab results were available. Steve Ellis reported to me a conversation he had with Dr. Kish from the University of Idaho in which Dr. Kish reported that he had seen present an infection rate of 77% in the population of grasshoppers collected that were still alive at the time of the collections. I think this data although still not completely finished is significant enough to be mentioned in this EIS and has certainly caused many people to rethink some of their attitudes about the effectiveness of Nosema, both in the first year and in the years to come. I think it lends needed support to the fact which we have been pointing out for so long - that Nosema locustae has a very very significant place in the management of grasshopper populations. I would suggest that you verify this information if you feel it is necessary and include it in some way in the EIS.

My Comments:

Ref. Page XVI PP1

13-2 1. You state that because of its relatively high cost per acre Nosema would have high utility where environmental considerations were of primary importance. While I agree with the fact that Nosema does have high utility where environmental considerations are of primary importance, I do wish to make it clear that the increased usage of Nosema thereby increasing the production of commercial companies that manufacture this product will mean lower costs on a year to year basis. The cost for Nosema within a very short time will easily be equivalant in cost to any chemical insecticide. Combine that with the fact that you get two to three years leverage out of a Nosema application and you divide the cost of Nosema by 2 or 3 times. That makes the 1987 applications at a cost lower than chemical insecticides.If there is a commitment from the Federal Government to purchase between 5 and 10 million acres of Nosema a year for the next 5 years as there has been a commitment by the Federal Government to purchase chemical insectides on that same basis, you would find that the cost for Nosema locustae would be significantly lower than the chemical costs. The obvious additional benefit of fitting in everywhere where there are environmental concerns has merit because I think history over the last two years has shown that the environmental concerns are becoming more and more widespread over all the areas treated for grasshopper infestations.

Ref. Page 1-10 PP3

13-3 2. I am pleased to see that there is an exception to the 10,000 acre minimum block size requirement allowed under conditions of incipient infestation. I am also pleased to know that APHIS will respond to requests to treat these smaller infestations or hot-spots to avoid having to treat larger areas later. This is the whole point of grasshopper management programs, trying to prevent forest fires rather than trying to put then out, and it is in this situation exactly that Nosema fits the bill for cutting-off grasshopper populations before they get out of control. I would hope that you would mention in this paragraph that Nosema would be utilized to the greatest degree, rather than chemicals, for incipient infestations.

Ref. Page 2 PP5

13-4 3. Elimination of an alternative consisting of biological methods alone, does not seem justified. It was clearly an alternative in the 1986 supplemental EIS. The reasoning behind this elimination are: 1) Methods for making consistant and accurate predictions of grasshopper outbreaks are lacking. (This applies both to biological and chemical). 2) Nosema takes longer than chemicals to effect population reductions. (Still can help meet the continuing need for control of outbreaks in the year of application). and 3) The fact that commercial production of Nosema is not currently great enough for it to be used on all the acreage treated by APHIS in this cooperative program. This is an inadequate reason not to utilize this as a separate alternative. The more Nosema is used the more production will increase, and within a two year period, production of Nosema could be great enough for it to be used on all acreage treated by APHIS in its cooperative program.
The point is well taken that use of Nosema is one of the several operational methods included in the IPM alternative.

Ref. Page 2-20 PP2

13-5 4. Nosema Bait and Carbaryl Bait mixtures for use in the program is a very good idea. Just because the Nosema Bait and Carbaryl Bait mixture is not registered by EPA should present no problem if the Nosema Bait and Carbaryl Bait are used in alternate swaths which has much more effect than a Nosema Bait and Carbaryl Bait mixture. Both are currently registered for use separately on grasshoppers in this EIS. The method has been successfully used in Argentina. There's no need to make the grasshoppers sick that are going to die from the Carbaryl. I support that any additional testing to assess the potential usefulness of this combination in the IPM alternative and would hope this method of chemical and biological management could be used very shortly.

Ref. Page 2-25 PP2

13-6 5. The statement that chemicals are most cost effective but have the potential for more adverse environmental impacts is made in this paragraph. No one questions that chemicals have a potential for more adverse environmental impacts. Cost effectiveness of chemicals and Nosema on a one year head to head comparison at this point show chemicals as being somewhat cheaper. Again, the increased use of Nosema and the lowering of the production costs involved in this method will very shortly make Nosema the equivalant in cost to chemicals. Add to that the fact that Nosema is a viable force in grasshopper management for two or three years puts the true cost of a Nosema application significantly less than chemical.

Ref. Page 4-8 PP5 and Page 4-0 PP5

13-7 6. Your statement that Nosema does not reduce grasshopper populations and thus vegetation loss as quickly as chemical methods and therefore has an indirect effect of increased damage by grasshoppers to rangeland vegetation in adjacent crops in the year of application is true. It should also be noted, however, that over the period of the summer, an application of Nosema will save as much forage as chemical insecticides (Onsager). It is also important to note that severe damage will occur to vegetation if there are multiple hatches in grasshopper populations. If some of those hatches occur after a chemical application is made, no control would be effected on the late hatching grasshoppers, whereas, a Nosema application can have some significant effect on any later hatches that would occur during that year due to the spread of disease and even save more forage.

Ref. Page 4-10 PP1

13-8 7. It is important to note that because some of the chemicals used may not be registered for use on crops you anticipate leaving a 500 foot buffer zone maintained around these areas. Nosema has no such restriction and could be very effective in covering those buffer zones.

Ref. Page 4-76 PP1

13-9 8. It is true that at this particular stage in the development of Nosema as a commercial product, it is more expensive than chemical applications but, if you will note over the last five years the cost of Nosema has gone from over $12.00/acre to 3.75/acre while the price of insecticides has risen. Increased usage of Nosema as mentioned earlier will make the cost to the end user including the government go down significantly.

Ref. Page 4-78 PP3+4

13-10 9. It is important to note that Nosema locustae causes no impact on producers of honeybees in any way nor any impact on alfalfa cultivators.

Ref. Page 4-83 PP3

13-11 10. You mention the fact that killing non-target insect species and secondary impacts on wildlife species which depend on grasshoppers and non-target insects for food are unavoidable adverse impacts of grasshopper control. They are only unavoidable if there are chemical insecticides used. They are completely avoidable if Nosema is used in those situations.

Ref. Page 5-2,5-3,5-4 all

13-12 11. Please note that in your comments on endangered and threatened species, critical habitat requirements, on fish and wildlife conservation requirements, heritage conservation requirements, wetlands protection requirements, and recreation resources requirements, there are statements made saying that there are very basic concerns that people have in regard to chemical usage on these subjects, but no mention is made of the fact that Nosema has no adverse impact and in fact is very compatable and allows a high degree of comfort for any environmental concerns people may have in these particular areas. I suggest that Nosema be recommended for any buffer areas around cropping or the above mentioned to address grasshopper populations that reproduce and thrive in those areas.

13-13 It is important to note also that the larger the acres used the more effective Nosema is as a grasshopper management agent. To date, no real truly large acreages have been applied, and by large acreages, I mean several hundred thousand acres at a time. In those situations you have an even greater impact on the whole complex of grasshoppers and the benefits of Nosema as a long term management tool will be more clearly understood and appreciated.

Thank you for the chance to comment on the Draft EIS-1987.

Best regards,

John Evans

John Evans

Sheridan County Weed and Pest Control District
P. O. BOX 732 — AIRPORT ROAD
SHERIDAN, WYOMING 82801

December 12, 1986

PPQ-APHIS-USDA
Charles H. Bare
Room 663 Federal Building
Hyattsville, Md 20782

Dear Mr. Bare,

We have reviewed the Draft EIS for Rangeland Grasshopper Cooperative Management Program.

Our comments are directed mainly at the draft operational procedures found in pages 2-27 through 2-31.

Table 2-1 Operational procedures

ALL METHODS

14-1 #9 Do not conduct any operations within ¼ mile of peregrine falcon or bald eagle nesting site.

AERIAL BROADCAST APPLICATIONS (Chemical and Biological Methods)

14-2 #2 Who's responsibility is it to certify the aircraft, dispersal equipment and pilots qualifications?

14-3 #4 What is notification? Will news releases meet this requirement or are we talking letters to everyone?

BAITS (Chemical and Biological Method)

14-4 #5 Do not apply within ¼ mile of peregrine falcon or bald eagle nesting sites.

CARBARYL BAIT

14-5 b. Leaving 200 feet untreated from any body of water does not seem to be very practical. In many areas leaving this distance due to water densities would leave to many untreated acres to have any kind of effective control.

ULTRA-LOW-VOLUME AERIAL APPLICATION (Chemical Methods)

14-6 #1. To minimize drift and volatilization, do not use ULV sprays when wind velocity exceeds 5 miles per hour not 10 miles per hour.

14-7 #3. The work wet needs clarified, does it mean a dew on the vegetation or what?

14-8 #10. Why 500 feet from any body of water identified within the operation area?

RCVD. [illegible]

14-8 In areas with significant amounts of water we cannot afford to flag out these areas. Also, I am afraid we would again be leaving too much untreated areas for a program to be effective.

Alot of grasshopper programs occur in true rangeland situations, but we also have programs in our ranges occuring along mountains and foothills where more water occurs.

14-9 #11. This needs clarification as to what is a high water table? A high water table can be when you find water two to three feet below the surface.

14-10 #14. PROTECTION OF BEES:

b. This could be tied in with pre-flights with the pilots prior to spraying an area.

14-11 d. This doesn't appear to be a feasible alternative, crops and weeds come into bloom all season long. We sign up spray areas in early spring, spray in mid summer. Again, we don't have man power or resources to flag out these areas. Also, you are again allowing damage to crops and ranges plus leaving a certain percent of hoppers in an area.
In some situations I could invision entire spray blocks falling apart due to this restriction.

ULTRA LOW VOLUME AERIAL APPLICATION (Chemical Methods)

14-12 #3. This seems to be a good idea, but we have some concerns as to the practical application of this proposal.

14-13 #4. PROTECTION OF BEES:

When control program boundry areas are established, generally speaking you are within a few days of letting a spray contract.
The beekeepers have been notified once and if they are a qualified beekeeper they will keep in contact with the project supervisor.
I feel that a second notice is not needed, but if we have to give a second notice 3 days is plenty.

I would like to thank you for the opportunity for us to respond to this document. Should you have any questions, please feel free to contact me.

Sincerely,

Robert R. Benjamin

Robert R. Benjamin
Supervisor
Sheridan County Weed & Pest
Control District
RRB/bh

15

BIG HORN COUNTY

HARDIN, MONTANA 59034
December 4, 1986

Mr. Charles H. Bare, Staff Officer
PPQ-APHIS-USDA
Federal Building, Room 663
Hayattsville, Md 20782

Dear Mr. Bare:

The Big Horn County Montana Grasshopper Control Committee requested that I write to to you in order that we could express our feelings, concerns and reactions regarding the **Rangeland Grasshopper Cooperative Management Program - Draft Environmental Impact Statement - 1987.**

15-1 As you are aware, The Big Horn County Rancher Grasshopper Control Committee was instrumental in the coordination and spraying of over 1.5 million acres of land for grasshopper control in our County in 1986. In 1985, we sprayed over 749,000 acres. Following is a brief breakdown of this years program:

*Total Acres Sprayed:	1,526,902 acres
Total Cost of Program:	$2,491,807.10
* Private Range	208,756 acres
Private Farm	8,786 acres
State Land	15,973 acres
B.I.A. Trust	1,293,387 acres

In comparison, in 1985 we had 749,248 Total Acres sprayed for a Total Cost of $1,193,605.00.

This gives you and idea of the involvement the ranchers have in the Grasshopper Control Program in our County and, hopefully, gives you a better understanding as to the reasons for our comments in regards to the Draft Environmental Impact Statement as written.

15-2 Generally we support your Agencies (preferred) position, Alternative 3, Integrated Pest Management, as the most viable alternative that was presented in the DEIS.

15-3 However, we have serious reservations regarding the use of Nosema locustae as an immediate control measure due to the following reasons:

1. Data indicates that Nosema locustae may be beneficial for long term control and that it is species specific with no data presented as to what species of grasshoppers it does

RCVD. FOSS 12-15-86

15-3 effect. Does it effect the species _Melanoplus sanguinipes_, _Melanoplus differentialis_, _Amphitornus coloradus_, _Melanoplus bivittatus_, _Ageneolettix deorum_ or _Melanoplus ferurrubrum_, all of which have been identified in Big Horn County, which borders the State of Wyoming.

15-4

2. When grasshopper control is needed on our range land, it needs control N-O-W! Our ranchers cannot wait for, as research indicates, four to six weeks for _Nosema locustae_ to effect only 50 percent of the "various species." We have verified populations of grasshoppers, by APHIS-PPQ, of 40, 60, even over 90 grasshoppers per square yard. The amount of forage that these grasshoppers would consume during the four to six weeks would be tremendous and, further, we would still have 20, 30, even 45 grasshopper per square yard left, which would decimate our range lands.

3. Economically, the use of _Nosema locustae_ would be unacceptable to our ranchers. They would be paying twice for control, once for a product that **M-A-Y** or may not work, then for chemical control that has been proven to be effective in reducing the populations to an acceptable economic level.

15-5

4. We urge, for long term preventive control, additional research into _Entomophaga grylli_. We feel that research effort should be directed towards this area as well as some of the _Entomopox Viruses_, particularly those that effect the most destructive species of grasshoppers on our rangeland and crop land.

15-6

We will not comment on the Cultural/Mechanical Control Methods detailed in the IPM Alternative as this is counterproductive to the 1985 Farm Bill, particularly the Conservation Reserve Program. This control method would not only increase topsoil loss due to erosion, it would be highly impractical given the topography of the land in Big Horn County. This method of control is also not cost effective as research data has stated. (USDA 1975)

Although we in the Big Horn County Montana Grasshopper Control Committee generally support your Preferred Alternative Number Three - IPM, we do have a serious concern with the OPERATIONAL PROCEDURES as stated in Table 2-1 of the aforementioned DEIS - 1987.

We take particular defference to the sections entitled BAITS (Chemical and Biological Methods) and ULTRA-LOW-VOLUME AERIAL APPLICATION (Chemical Methods).

First,BAITS:

15-7

1. Line 6, "b" and "d". These statements need to be changed and more specific descriptions of "reservoirs, lakes, ponds and springs." Does this infer that if there are

any of the above located in the control area, that no control will be undertaken with Carbaryl Bait? We feel that this should be changed to exclude water sources that are of a temporary nature and used for stock watering purposes and do not contribute to aquatic or fish habitat. If not, the way it is stated would preclude any control in the State of Montana, or, more particularly, in Big Horn County.

15-8

In line "d", you state that no Bait control methods would be used "where the water table is high, where leaching or surface runoff is likely." This again would preclude any Bait control methods being used in the State of Montana or in Most all of the United States, where any surface runoff could occur as this happens everywhere it rains. This must be quantified and common sense must prevail.

Secondly, ULTRA-LOW-VOLUME.

15-9

1. Line 10 and 11. Our concerns are identical with line 6, "b" and "d" as written above. You could interchange "Malithion", the ULV chemical most prevently used in Big Horn County Montana, with "Carbaryl Bait." If this remains as is in the DEIS, and enforced, there would be no control programs in Montana, Wyoming, Colorado or Idaho.

15-10

2. Line 14, "a". The question that arises is "WHO" is responsible to send these notices out and what happens if a Bee Keeper refuses to move his bee's, is the program shut down? Who is responsible for accidental bee kills?

15-11

3. Line 14, "d". Again, this statement would effectively shut-down any control measures as, normally, when control measures are instituted, noxious weeds are in full bloom. What about wild bees?, are they included in the survey? Who determines if there are bees two miles away from a "homeowners" hive? These are just some of the questions we have. Remember, we treated over 1.5 million acres in 1986; if we or APHIS-PPQ, came under these restrictions, there would be no grasshopper control program in Big Horn County. No control program - No Livestock industry!

It is our contention that more Indian ranchers and non-Indian ranchers alike would benefit from a control program by spraying than would the three registered bee keepers in the County be harmed if we were under these strict Operational Procedures. The benefits to the majority must be up-held as they are the majority of taxpayers in the County and contribute the most money for a control program.

15-12

We would like to thank you for the opportunity to comment on the Rangeland Grasshopper Cooperative Management Program - Draft

15-12 Environmental Impact Statement - 1987. We have enclosed, for your information, a copy of the presentation we made a Salt Lake City, Utah, on October 28, 1986, wherein we suggested specific recommendations on how the APHIS - PPQ Grasshopper Control Program could be improved.

If we can be of any further assistance to you, please do not hesitate to contact us.

Yours very truly,

Kirk M. Barnette

Kirk M. Barnette
Big Horn County Extension Agent
Secretary, Big Horn County Grasshopper Control Committee

cc: Brad Spear, Chairman
Hale Jeffers, Vice Chairman
U. S. Congressman, Ron Marlenee
Grasshopper Control Executive Committee

16

Platte County Weed and Pest Control District
In Co-operation With Wyoming Department of Agriculture
Box 775
Wheatland, Wyoming 82201

December 10, 1986

Mr. Charles H. Bare
Staff Officer
PPQ APHIS USDA
Federal Building Rm. 663
Hyattsville, MO 80782

Dear Sir:

Recently I have reviewed the Rangeland Grasshopper Cooperative Management Program - Draft Environmental Impact Statement - 1987. Regretfully, I find that the resulting operational procedures (Tables 2-1 and 2-2) to be at least highly impractical and at worst impossible to work under. In Wyoming, as in most western states, there are a few people in county and state government who are responsible for signing up and spraying over one million acres. Last year over 2.5 million acres in Wyoming alone was sprayed. We do the best professional job we can do with the number of personnel available.

The operational procedures you have come up with are entirely out of line. It would be nice to have thousands of people working on grasshopper spraying programs in Wyoming, but we have less than 50 people for the whole state. Furthermore, if your prodecures were followed there would be so much land taken out of a proposed spray block that the area sprayed would be reinfested entirely by the land taken out of the block. It would be a waste of money - federal, state and local.

I am enclosing a topographic map of an area in Platte County that will probably be economically infested this next year. This map covers approximately 35,000 acres. I challenge you or the people who have come up with the operational procedures to apply these regulations to this area. I have not picked this area because I feel it would give you problems. This is a typical portion of the land in our county.

I am responsible for the control of designated weeds and pests in our county. We have about four employees, including myself, available to work on a grasshopper program. We normally share one state employee with a neighboring county during the summer for the grasshopper program. I'll allow you to use five employees also.

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Please remove all the non-sprayable lands out of this map - show us what areas would be removed! If you would like further information on where eagles, falcons, etc. may be nesting, I'll try, but maybe you should inspect it in person to make sure. GET THE IDEA! Yes, come out in person and flag out these areas out of the spray block. At the most, you have one month to complete this task. Have you completed this work yet? Good! Now take this proposed spray area to several aerial applicators to see how much per acre they will charge to do the job. Just to put this in perspective - this area contains approximately 35,000 acres. In 1984 we sprayed nearly 300,000 acres in Platte County alone!

Please - we need common sense and ways to eliminate the red tape, not more regulations that will virtually eliminate the effectiveness of a grasshopper spraying program. It is time to go back to the drawing board. This time, talk to the people who have been and are involved with this program.

Sincerely,
Bob Shoemaker
Robert B. Shoemaker
Supervisor
Platte County Weed and Pest
Control District

Encl.
RS;mj

17

IN REPLY REFER TO:
1797 (930)

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
222 North 32nd Street
P.O. Box 36800
Billings, Montana 59107

December 23, 1986

Charles H. Bare, Staff Officer
PPQ-APHIS-USDA
Federal Building, Room 663
Hyattsville, Maryland 20782

Dear Mr. Bare:

17-1

My staff has completed its review and believes that this draft Environmental Impact Statement (EIS) is a well written document. It evaluates commonly used chemicals for controlling grasshoppers and Morman crickets on rangeland.

Some form of preseason coordination between BLM and Animal and Plant Health Inspection Service (APHIS) is necessary early in 1987 to ensure needed actions occur in a timely and effective manner. Timing of application is very critical when biological control methods are used or a combination of biological and chemical methods are planned.

17-2

We believe increased emphasis to promote biological control methods, as an integral part in the control program, is necessary. Alternative 3, (Preferred Alternative) - Integrated Pest Management, would allow biological or chemical methods to be selected singly or in combination for grasshopper control.

More research and testing of biological control alternatives is now appropriate. Chemicals used in control efforts adversely affect all insects, adjacent water quality, soil micro-organisms, and wildlife that use insects for food. Chemical companies do an excellent job of promoting the use of chemicals; however, there is no apparent similar emphasis when encouraging the use of biological controls.

We strongly urge that APHIS actively pursue a program of *Nosema* application in 1987 on federal wildlands where past grasshopper populations indicate potentially high numbers. Specifically, these are areas with sensitive environments such as wetlands, streams, riparian habitats, and locations near human habitation. We could assist in the evaluation of the overall program to identify such sensitive environments.

RCVD. FOSS 12-30-86

17-3 On page 3-26, the last word of the first sentence under "Soils" is misspelled. The word is "aridisol" not "audisol."

We appreciate receiving the opportunity to review this EIS.

Sincerely,

John A. Kwiatkowski
Deputy State Director, Divison of Lands and Renewable Resources

cc:
DM, Lewistown DO

18

STATE OF UTAH

Department of Agriculture
GOVERNOR'S CABINET

350 North Redwood Road
Salt Lake City, Utah 84116
(801) 533-5421

NORMAN H. BANGERTER
Governor

MILES 'CAP' FERI
Commissioner

December 22, 1986

Mr. Charles H. Bare
USDA, APHIS, PPQ
Room 663, Federal Building
6505 Belcrest Road
Hyattsville, MD 20782

Dear Chuck:

18-1 Enclosed are our comments on the Rangeland Grasshopper Cooperativ Management Program Draft Environmental Impact Statement for 1987.

First we want to congradulate you on a much improved propose successor to the current E.I.S. as supplemented. Second thank yo for the opportunity to review and comment on this Draft E.I.S.

Our overall impression of the Draft E.I.S. is a favorable one However, there are some areas of concern and we have som suggestions for improving not only the Draft but the quality an effectiveness of future control programs.

Our suggestions are contained in the following pages. It contain our comments, changes, and definitions.

Once again we appreciate the opportunity to review this Draft EIS.

Sincerely,

Edison Stephens
Deputy Commissioner

Paul R. Daniels
Director Plant Industry

Al Rivas
Consultant

PRD/lac

Enclosure

RCVD. PPSS 12-30-86

COMMENTS ON THE E.I.S. DRAFT

18-2 The research effort and analysis that have been done are impressive, however, we do not understand how the conclusions you have reached and the constraints you propose are justified by the data and information you cite. As you indicated on 5-1, 2nd paragraph, 4th line; "NEPA requires that federal agencies assess the impact of major federal actions significantly affecting the quality of the human environment." We believe the key word here is "significantly". It would seem obvious a distinction was intended between those actions which are insignificant or average and those which are important or likely to have an especially adverse effect. Yet as we read the draft it becomes quite clear that the proposed actions, even without all of the various mitigation measures proposed, are not likely to "significantly" affect the environment.

The following quotes from the draft are provided in support of this comment. "All three chemicals are rapidly degraded and would not have significant impact on soils or soil organism . . . direct spraying is not expected to have any adverse impact on vegetation". (Page xx, Summary of Impacts on Soils and Vegetation by Alternatives). "Field studies indicate that there have been no significant impact on wildlife in areas treated with chemicals at application rates similar to those proposed for the current program." (Page xxi, Summary of Impacts on Wildlife by Alternatives). On page xxii under the Summary of Impacts to Water and Aquatic Species, the points are made that outside of jettisoning a load of insecticide into a reservoir, and if a 500 foot buffer between the spray area and water bodies was used, adverse effects if any would be temporary.

All of the examples cited above were taken from the Chemical Control Alternative section, page xxi and xxii of the various summaries. Actual impacts under the IPM alternative, the one selected, would be proportionately less.

18-3 One of the most troubling aspects of the Draft is the unnecessary mitigation criteria established for this program are not only unduly restrictive but will result in inadequate treatment and thus perpetuate the need for more treatment. Specifically the 500 foot buffer adjacent to water and some crops. Your risk assessment page 4:43-49 does not support the need for such a buffer and the EPA labels do not require it. Neither EPA or USDA require such buffer in connection with farm crops or other uses, the areas where the overwhelming majority of bodies of water, wildlife, and pesticide use occurs. Furthermore there is nothing in the Draft to support the use of 500 feet as opposed to 600 feet, 300 feet, 20 feet or half a mile. We are not opposed to the use of buffers where warranted, however, if USDA actually believes these buffers are necessary to protect the environment then we believe they should be applied to all uses of these pesticides. If USDA believes the constraints in this Draft should not apply to those areas where the overwhelming majority of bodies of water, numbers, and species of wildlife and pesticide use occur, we would like to know your rational. It would seem wise to determine the actual effects on egg hatchability rather than continue to proceed under the assumption given in paragraph 4, page 4-36 of the Draft E.I.S. 1987.

18-4 Other examples of unrealistic constraints are items 11 and 14d on page 2-30. Not only do we believe that if these constraints should apply to our control programs they should apply to everyone, but we have the following additional comments. Regarding item 11 above, just how do you define a "high" water table, how deep, how extensive, and how is one identified?

18-5 With regard to item 14d; even though a conscientious, good faith effort to eliminate adverse spray effects to managed bee populations is made, no one can guarantee wild bee populations, including wild honey bees, will be kept out of prospective spray areas. Some weed would likely be blooming during optimum spray time and if there are any bees within three to four miles they could very likely be visiting the area.

18-6 Another constraint about which we have concern is item 9 on page 2-27 and item 5 under Baits on 2-29. Basically we support this constraint at least until further research should show there is a need for expanding or reducing it. However, we do not agree that this constraint should be applied to new hack sites or future nest sites established in addition to those existing in 1986. Our concern is that well intentioned efforts to establish new hack sites or nesting sites should not be permitted to exclude needed treatment areas.

18-7 We cannot agree that unlimited and arbitrarily selected sites should be allowed to exclude infestation areas from needed treatment. For example the Draft deals with egg hatchability on page 4-36 and Summary xxii. Lets also get a realistic approach to what will probably happen. First of all, acetone is not going to be used in the project. Second eggs exposed in the project would not be injected and last it is highly unlikely 100% of any spray material would ever be absorbed into an egg. We believe it would be helpful if the reader knew the probable effects and not just the conservative estimation effects.

18-8 I would also be helpful if the reader was told that while the risks stated in paragraphs 3 and 4 on page xxiii are a certain percentage less than the risk he already faces from eating food crops treated with these material. Another approach would be to put the "increased" cancer risk in perspective with the exisiting cancer risk without the project. For example, one in four persons now get cancer during their lifetime without the project. The risk analysis used for the project should show that for every million people exposed to malathion instead of 250,000 getting cancer, 250,005 <u>may</u> get cancer. Then put it in terms of what you realistically might expect (without all the conservative assumptions).

18-9 Another area of concern we have is with the operational and research components of the IPM alternative over the planned 5 year implementation (Table 2-4). There does not for example, appear to be any place in the current plan stating what research can be conducted most effectively.

Areas of research might involve small scale control projects that treat bands of Mormon crickets before they disperse. There also is a need for additional treatment evaluation so that we can know rather than guess what impacts are likely to occur.

18-10 The impact ascribed under no control on page 2-35, argues strongly for control within the buffer area adjacent to water. The serious erosion problems, increased sedimentation, turbidity etc., could adversely affect the aquatic habitat and life forms more than the pesticides used in spraying.

18-11 In summary we believe that if constraints are necessary they should be based on facts. The facts given do not support the constraints proposed. If additional information is needed we suggest research be conducted to obtain it. For example a large reservoir in Utah will be treated to kill all of its fish in 1988. That reservoir would be an ideal place to conduct test spraying to the waters edge in 1987 to determine the effects if any on the aquatic population. Similar tests could probably be conducted elsewhere.

Another troubling aspect of the Draft is that the conservative criteria used throughout do not present the reader with a realistic appraisal of what is likely to happen. We applaud the use of conservative assumptions.

<u>CHANGES</u>:

We suggest the following changes:

18-12 1. On pages xi, xii, and elsewhere the Draft EIS is referred to as "This Programmatic Environmental Impact Statement (EIS). . ." or "This EIS. . .", and that new methods will be ". . .tiered to this EIS." At least in the Draft EIS such comments are incorrect. References in the Draft to "tiering", "supplements" or "the EIS" should make clear that they are to the Final EIS.

18-13 We suggest that common names be given as well as the scientific names at the top of page xx.

18-14 2. We believe the meaning of the last complete sentence on page xxi would be clarified if the word "overall" was inserted between the words "affect" and "wildlife".

18-15 3. On page xxii, the first two words are "avian species". Changing "avian species" to "birds" would be an improvement.

18-16 4. The last sentence of the last full paragraph on page 2-6, should have the word "designated" inserted between the words "and" and "buffer".

18-17 5. On page 3-26, the last word of the first sentence under the heading <u>Soils</u> is "audisol"; We believe that should be changed to "aridisol".

18-18 6. On page 3-6, the first paragraph under <u>Topography and Climate</u> makes reference to "180 feet below sea level". The first partial paragraph on page 3-28 makes reference to "280 feet below sea level". One of them needs to be changed.

18-19 7. The third sentence of the first paragraph on page 3-36, refers to "pronghorned sheep". We aren't sure what is intended here, but you probably mean "bighorned sheep".

<u>DEFINITIONS</u>:

18-20 1. Define the word "crops" as used in the last full paragraph on page xx. We presume you mean "sown agricultural crops" but there are other types of plants or animals or their products such as pinon nuts that are indeed crops. We doubt that you mean to exclude pinon trees from being sprayed.

18-21 2. The phrase "bodies of water" as shown on page xxii and elsewhere in the Draft needs definition. We believe the statement in the first paragraph on page 3-14, that refers to the ". . .operational requirement of a buffer 500 feet wide along any permanent water body. . ." is a help.

18-22 3. We question your designation on page 3-21, of the ringtail as a "chief furbearer". It may not be a matter needing definition but it seems highly unlikely that the ringtail is more of a furbearing species than the coyote which wasn't even mentioned as such.

18-23 4. On page 3-27, mention is made of Navajo Lake. Since there is more than one Navajo Lake some further designation or location would be helpful.

19

GOVERNOR
TONEY ANAYA
DIRECTOR AND SECRETARY
TO THE COMMISSION
HAROLD F OLSON

State of New Mexico

DEPARTMENT OF GAME AND FISH

STATE CAPITOL
SANTA FE
87503

December 19, 1986

Charles H. Bare, Staff Officer
PPQ-APHIS-USDA
Federal Building, Room 663
Hyattsville, MD 20782

Dear Mr. Bare:

My staff has reviewed the Draft Environmental Impact Statement (DEIS) addressing the Rangeland Grasshopper Cooperative Management Program for 1987. My comments will be directed at the APHIS Rangeland Grasshopper Control Program and how the proposed action as presented in the DEIS may negatively impact fish and wildlife and their habitat in New Mexico. These comments do not necessarily represent, nor should they be construed as constituting, the official State position on the program.

19-1 In the past the program has directed its resources towards solving annual infestation problems. This commitment of resources to addressing the problem on an annual basis is costly, environmentally disrupting and shortsighted. This approach focused on crisis management rather than preventive management. The lack of effort to achieve long-term solutions to this problem resulted in great expenditure of financial resources at the expense of the environment. Page 1-1 of the DEIS states "Significant forage and crop losses still occur despite control measures by government agencies and individual ranchers. In 1985, for example, grasshoppers were the most widespread and caused the most damage since the major outbreaks of the 1930's". After almost 50 years of continuous application of untold quantities of insecticides, grasshoppers continue to cause significant damage to rangelands. This should be evidence enough that the program as practiced for over 50 years has not been successful in achieving anything but temporary localized population control.

RCVD. PPSS 12-30-86

19-1 This DEIS suggests that attitudes and objectives are changing from past practices of merely maintaining the status quo, as attested to by the proposed Integrated Pest Management (IPM) alternative. The stated objective of IPM not only proposes using a variety of methods to achieve grasshopper control, thus lessening dependence on chemical controls, but it also proposes research into methods for achieving long-range control and the elimination of parameters that contribute to, or promote uncontrolled grasshopper population increases. Assuming this is the true intent and direction the APHIS program is now striving for, and to which resources will now be allocated, I fully endorse this alternative and initiative.

19-2 All to often in the past APHIS has justified control measures on anticipated economic losses to livestock growers. Determinations have been made based on anticipated loss of resources that are exploitable by livestock. Intrinsic values of rangelands have not been considered. Substantial investments have been made to control grasshoppers without a complete analysis of the associated cost-benefits. APHIS may be mandated to implement controls if certain criteria are met, but the overall cost of implementation could easily exceed the loss of potential revenue to the livestock producer. This is especially true in rangelands that have limited forage available for consumption by livestock. This problem is exemplified in arid states such as New Mexico. When control measures are proposed for an area, the cost effectiveness must be fully assessed. In this DEIS the concept of cost effectiveness is not completely addressed. The decision to apply control measures to an area should be based on a cost-benefit basis rather than the fact that the number of grasshoppers exceeds 8 per square yard, and the cooperator agrees to it.

19-3 An important concept that needs to be included in the cost-benefit analysis is the overall impacts that control measures will have on the environment. In addition to the cost of the program relative to the anticipated loss of livestock forage, the decimation of non-target invertebrates through the use of chemicals and the resultant effects further up the food chain need to be calculated. Other considerations are the direct impacts on vertebrates and the effects exerted on the environment from cumulative impacts and synergistic effects that may accrue through the years.

19-4 Since its inception, the APHIS grasshopper control program has relied almost exclusively on chemical means of control.

19-4 Until recently this has probably been a politically acceptable means. If long-term objectives and benefits are brought into perspective, however, political realities may change from the short-sighted gains, and perhaps that is the direction APHIS is now moving. I hope, however, that factual economic aspects can be put into perspective. As APHIS implements control programs in 1987, the least expensive method should not necessarily be the control method of choice. For example, the DEIS shows use of the chemical acephate being the least expensive control method per acre. Conversely, nosema bait the most expensive. However, when the overall costs are calculated, including environmental costs, nosema bait may be a viable alternative.

19-5 The achievement of long-term control of grasshopper populations, prevention of population outbreaks, and prevention of economic forage losses should be the main objectives of APHIS. In order to achieve this, APHIS must work toward a true understanding of the complex interactions and dynamics of rangeland grasshopper populations and the associated factors that influence uncontrolled population increases. The ecological principle that complexity tends to influence environmental stability could be one of the keys to this. Man's past land management practices have favored conditions that contributed to reductions in species diversity of rangeland plant communities. One outstanding example is overgrazing; a practice that typically results in the gross simplification of environmental complexity. This practice and associated management has resulted in man physically altering habitat to produce preferred livestock forage. In addition, direct impacts by livestock have tended to influence monotypic vegetation stands, and overgrazing has produced micro-habitat conditions that are conducive to successful reproductive efforts by grasshoppers. Overgrazing has been shown to induce grasshopper populations to expand beyond equilibrium levels. Perhaps a first step in achieving long-term controls would be to rectify those rangeland conditions that favor uncontrolled population increases.

19-6 The preferred IPM alternative proposes the use of chemical controls (acephate, carbaryl spray, carbaryl bait, malathion) and biological control (<u>Nosema</u> <u>locustae</u> bait). Unfortunately, the current plan still relies heavily on chemical controls. The reason given is that the production of biological control agents is limited with limited quantities available. The indication that biological control agent production is being increased to accommodate current needs is encouraging. Other proposed methods, i.e., other

19-6 biological agents, cultural/mechanical methods, various range management techniques, may not be used in this program until they are tested and proven effective. A component of the IPM alternative is to proceed with the evaluation of these methods. I strongly encourage APHIS to proceed with this evaluation process so that dependence upon chemical controls may be reduced in the near future.

19-7 Before applying control measures to a given area, a biological assessment should be made. Important factors that are observed at the proposed control site need to be considered when selecting a method. In this regard, I offer the following recommendations when selecting a control method for a particular site:

1. Chemical controls should not be applied to areas where concentrations of nesting birds are found.
2. The use of carbaryl bait should be avoided in areas found to support concentrations of granivorous species of animals.
3. Areas that support concentrations of wildlife should have biological controls applied rather than chemical controls.
4. In areas where concentrations of insectivorous species occur, biological controls need to be applied to avoid decimating non-target invertebrates and thus reducing impacts on insectivores.
5. Carbaryl should not be used for multiple applications in any given area.
6. In areas where multiple chemical applications are deemed necessary to achieve desired control levels, chemicals should be carefully selected and treatment applied only to "hot spots".

19-8 Page 4-38 implies multiple chemical treatments would only impact wildlife species by reducing insect populations. I disagree; the issue is not as simplistic as the document would have one believe. Impacts to wildlife will not only result from reductions in insect populations, but wildlife will be affected by other synergistic interactions.

19-9 Page 4-80 states that the total amount of insecticide applied by the APHIS program is relatively small compared to the total amount applied in the western states. This implies

19-9 that cumulative impacts resulting from APHIS controls should be negligible. Insecticides applied in the western states are not deposited solely by APHIS or by others in conjunction with APHIS. With this in mind, the concept of environmental tolerance or threshold level at which adverse environmental consequences may be expected needs to be evaluated. Insecticides used by APHIS and all other known users must be incorporated into the overall picture.

19-10 Proposed measures for the protection of federally listed endangered and threatened species appears to be adequate. Essential to the protection of these species is adequate information on distribution and critical habitat. Through the consultation process, most of this information is available. Of particular concern to my agency are state listed endangered species. I feel that further consultation is needed between APHIS and state agencies after site specific decisions have been made regarding areas to receive control measures. My agency is willing to provided information concerning species of state interest. However, until details addressing specific areas to receive treatment are made available, we are limited in the type of information we can provide.

19-11 The DEIS contains information describing the 1986 Pesticide Monitoring Sampling Procedures. There are no data presented in this appendix. Such information would be useful in making recommendations for the 1987 control program. Also, there is little indication that this monitoring program will be carried over into 1987. The opportunity to gather such data over an extended period of time could prove invaluable in making assessments and decisions of a procedural nature. In addition, the monitoring program should be expanded to gather more species specific data that will be used to answer many of the unknowns eluded to in this DEIS.

19-12 In summary, APHIS should lessen reliance on chemical controls and place more emphasis on methods that are more environmentally sound. Research into alternative methods of grasshopper control should be emphasized, as should expansion of the monitoring program. The long-range goal should be to reincorporate the natural biological factors that resulted in grasshopper populations being held in equilibrium. Factors that historically controlled grasshopper populations should be identified and enhanced. Certainly some uncontrollable environmental factors will result in sporadic population outbreaks, but those can be addressed with environmentally sound controls as needed.

19-12 I appreciate you affording the New Mexico Department of Game and Fish the opportunity to review and comment upon the Draft Environmental Impact Statement for 1987. If you have any questions, please contact Andrew Sandoval of my staff at 827-7952.

Sincerely,

Harold F. Olson
Director

rsj

cc: Denise D. Fort (Director, EID)
John Peterson (Ecological Services, USFWS)
William P. Stephens (Director, NMDA)
W. H. Baltosser (Chief, Biological Services Div., NMGF)
Daniel Sutcliffe (Chief, Game Management Div., NMGF)

20

DEC 30

AUDUBON SOCIETY OF PORTLAND

A Branch of National Audubon Society

PHONE 292-6855 • 5151 NORTHWEST CORNELL ROAD • PORTLAND, OREGON 97210

Mr. Charles Bare
Staff Officer
PPQ-APHIS-USDA
Federal Building, Rm. 663
Hyattsville, MD 20782

Re: Comments on Rangeland Grasshopper Cooperative Management Program Draft EIS 1987

Dear Mr. Bare:

Portland Audubon Society is a 6,000 member organization of people who are interested in preserving wildlife and their habitat. For the last several years, we have had an active group of members with particular interest in BLM management of western rangelands. We are pleased to have an opportunity to comment on this draft EIS.

20-1 We are also pleased that you have selected Integrated Pest Management (IPM) as your preferred alternative. According to the DEIS, your primary aim, under the preferred alternative, would be "to develop means by which outbreaks could be predicted and prevented and to develop alternative methods of grasshopper control (for both prevention and suppression) that minimize the use of chemicals." We support your goals.

Historically, APHIS funds have been used almost entirely for programs related to the chemical control of outbreaks. The DEIS sets a new mission, but we are concerned that program planning and implementation won't follow. We think that you should strengthen your commitment to IPM in several important ways in this document.

Strengthen Commitment to IPM.

20-2 1. The final EIS is used as a guiding document for program personnel and cooperators. The DEIS finds that environmental impacts are reduced with IPM, but then leaves open the possibility of relying only on chemical control. There should be a strong commitment to use of *Nosema locustae* and clear criteria for decisions on when to apply control methods and which to apply.

The standards are particularly important because site-specific EA's will be tiered to this document. Without clear guidance, program personnel may go back to business as usual.

20-3 2. Monitoring should include plans for research on the relationship of grazing management to grasshopper outbreaks, new biological methods, and the effectiveness of various kinds of treatments.

20-4 3. Because the grasshopper populations apparently peaked in 1985, APHIS and cooperators have an opportunity now to prepare a three to five year work plan really emphasizing prediction and prevention.

20-5 4. The DEIS refers to the need for cooperators' participation in studying prevention and prediction of outbreaks. There is no clear commitment from APHIS to lead this work. The APHIS program should make clear IPM aims and encourage cooperators to participate as a program requirement.

20-6 5. APHIS budgets should reflect the IPM priority for research on prevention, prediction, and biological control. We are sending our comments to Congressman Les AuCoin and Senator Mark Hatfield to seek their support for these budget priorities.

Strengthen Standards for Tiering Environmental Analysis.

20-7 We found, in our correspondence with the BLM, that they look to APHIS to perform analyses required by NEPA, and APHIS leaves some of these same analyses to site-specific EAs. For example, we asked the Oregon office of the BLM for cost/benefit analyses for the APHIS spray program in 1986. We were told (correspondence enclosed) that these analyses were done in the APHIS EIS. We couldn't find them in the previous EIS, and they also do not appear in this draft. The draft includes costs of control methods but no information or guidelines for assessing benefits.

20-8 Because site-specific analyses are required in order to complete any APHIS program action, this EIS should include specific guidelines for the required EAs. We would expect to see, at a minimum, the following documentation requirements:

20-9 1. Consideration of alternatives including no action, biological control, carbaryl bait, and chemical spraying. Cost/benefit analyses for each alternative and reasons for preferred alternative.

20-10 2. Criteria for selecting areas to be controlled to include, not only number of grasshoppers, but also condition of plant communities, presence of natural predators, presence of environmentally sensitive species and areas.

20-11 3. Implementation plans to include consideration of threatened and endangered species, environmentally sensitive species, and aquatic systems. The development of operational procedures and mitigation measures in cooperative agreements should involve public review.

20-12 4. The history of control programs in the area and results of site surveys from recent years.

20-13 Public involvement should be required throughout the year to discuss site survey information, likely areas requiring treatment, and environmental concerns in these areas. Typically, the public has had only a few days to respond to EA's when the ranching community has been involved throughout the year.

Include Information on Program History.

20-14 The DEIS fails to include information about how the program has operated. Surely you have gathered information about treatment effectiveness from previous years. Of greater concern to us, however, is the draft's use of statements such as, "these situations are unlikely and are not expected to occur," when discussing the possibility of sprays reaching aquatic systems (p. xxii).

These accidents have occurred with greater frequency than expected in a number of pesticide-control programs. What has been this program's history? In light of that history, what environmental impacts from accidents, drift, and runoff has the program caused? How can guidelines be strengthened to minimize these "unlikely" problems?

20-15 On Oregon BLM maps of control areas this year, small aquatic systems were rarely marked for exclusion. We suspect that far more chemicals reach aquatic systems than the DEIS indicates. This is another important reason for this EIS to set firm standards for program operation and for EA preparation.

Effect on Wildlife.

20-16 Although we would like to commend you for including risk analysis for wildlife as well as for human health, the data suggest that information is far from adequate about wildlife effects, and we disagree that wildlife impacts are not significant.

For several species, estimated doses of malathion and carbaryl exceed EPA risk criteria (p. 4-34,35). Although the DEIS claims that "populations" are not affected because effects are local, the survival of local populations could be jeopardized (4-32,32). We are skeptical that the risk to Lark Buntings can be adequately assessed by comparing data for Mallards (4-34), and data for herptiles seems to be almost entirely missing or ignored.

We think the DEIS should acknowledge where data are incomplete and further acknowledge that risk to wildlife is significant. Then, monitoring plans should include the needed research.

20-17 We support the U.S. Fish and Wildlife Service's request that migratory birds and nontarget insects receive careful research attention.

Scoping Comments Ignored.

20-18 Page xii of the Draft says that public participation has been an integral part of the preparation of this draft EIS. You have included the major categories of concern expressed by the public during Scoping at the start of EIS planning. We can't find, in the DEIS, however, where you have addressed some of these concerns. The final EIS should include consideration of the following points in Appendix D. (Numbering matches the DEIS.)

1. Site-specific criteria for selecting a control method.

20-19 3. Better guidance for preparing site-specific EAs.

20-20 8. More careful analysis of carbaryl/Nosema bait.

20-21 10. Questioning economic threshold of eight grasshoppers per square yard (this is used, alone, as a program standard by the Oregon BLM).

20-22 11. Program plan for researching and publishing known relationships between grazing management and grasshopper outbreaks (the Oregon BLM told us there was no known relationship).

20-23 12. Analysis of the effects of cholinesterase suppression on birds and fish.

Need for Better Prediction.

20-24 We support your research aim to improve your ability to predict outbreaks. Table 3-1 (p. 3-3) lists estimated acres requiring treatment based on adult survey along with acres treated in 1985. There were twice as many federal acres treated as estimated to require treatment. Is this because prediction is difficult, or does the discrepancy result from the lack of clear standards for the program? We note that the estimated acres and the actual acres are very much closer on private and state lands than on federal lands.

20-25 In summary, we support the aims of the DEIS preferred alternative, but believe you need to strengthen the EIS to assure that program planning follows this direction. We suggest that you include strong guidelines for program personnel and the program's cooperators. We are concerned that the DEIS does not acknowledge in the text the documented harmful effects of spray programs on wildlife, and we encourage you to acknowledge gaps in information which should be filled by research.

Thank you for the opportunity to comment.

Sincerely yours,

Linda Craig

Linda S. Craig
for the Conservation Committee
Audubon Society of Portland
2433 N. W. Quimby
Portland, OR 97210

SOUTH Dakota
Department of Agriculture

DIVISION OF REGULATORY SERVICES
Anderson Building, 445 East Capitol
Pierre, South Dakota 57501
Phone 605/773-3724

December 17, 1986

Charles H. Bare
Staff Officer, USDA-APHIS-PPQ
Federal Building, Room 663
Hyattsville, MD 20782

Subject: Comments Rangeland Grasshopper Cooperative Management Program, Draft EIS-1987.

Mr. Bare:

The following concerns and suggestions are advanced by the South Dakota Department of Agriculture relative to the Draft EIS referred to above.

1. **Alternative Strategies for the Management of Grasshoppers on Rangeland - Alternative 3, pages 2-15 through 2-25.**

21-1 South Dakota agrees that management of grasshopper populations is more desirable than the crises reaction system now employed. The state has funded a five-year research project toward that end. The 1987 control season will be the second year for the project. We feel that both APHIS and South Dakota state program personnel could benefit by joining resources as both strive to achieve the same end. Further, it appears from information available, that the APHIS IPM project needs to be reassessed to ensure it is an IPM project that will yield a sound management system in the time allotted. At present it appears to be a traditional control block approach in disguise with program structure and location based more on political considerations than biological.

2. **Summary of Environmental Consequences** - Table 2-1, Operational considerations pages 2-27 through 2-30.

<u>page 2-29, 6 (b) and pages 2-20, 10.</u>

21-2 While the careful application of the insecticides near water certainly must be a program consideration, the application restriction distances indicated may unduly restrict control programs in South Dakota. The concentration of stock dams and dugouts is often 1 per 1/2 section in many range areas; down to 1 per 1/4 section in others. With aerial application the need to leave such a buffer zone around all small man-made ponds could well result in programs being impossible to manage or structure.

21-3 A definition of perennial streams is needed. Does this refer to only streams that flow throughout the year or include those that may contain water all year but are reduced to pools during the drier seasons of the year?

Page 2-30, 14

21-4 <u>Protection of bees (c).</u> This procedural step may be unworkable or in many cases unneeded for the following reasons:

1. Leafcutter bees are not regulated in most states, hence the location and ownership of colonies is not known. Only an extensive survey of the control area would yield this information.

2. Essentially, alfalfa seed production is not a factor at the time grasshopper control programs are being conducted in most areas.

Suggest this item be deleted or changed to reflect notice to leafcutter and alkali beekeepers in the proposed control area(s) be accomplished by the news media insofar as practical.

21-5 <u>(d).</u> The Grasslands are dominated by 3 groups of flowering plants - grasses, legumes, and composites. Depending on how the terms "crop" and "weed" are defined, treatment would for all intents and purposes never be allowed as, except in winter, some plants are always in bloom and bees present.

Table 2-2, Page 2-31 <u>Protection of Bees:</u>

21-6 The 14-day suggested interval between notification and treatment, while nice in theory, is not practical. Many programs will be finalized and have to proceed on a schedule that will not allow this time lapse due to grasshopper developmental stage. Suggest general alert to all registered apiarists in potential treatment areas based on fall survey results and one notification letter listing proposed treatment dates when a program appears to be imminent for an area - to be sent no later than 5 days prior to commencing treatment.

3. Pages 3-18 through 3-40, **THE EIGHT RANGELAND ANALYSIS REGIONS.**

21-7 Consideration should be given to revising the regions used in the analysis to include a mid-grass (mix-grass) prairie category. The tall grass ecosystem does not extend as far west as outlined in the text and figures nor does the short grass prairie ecosystem extend as far east as depicted. The distinct phytosocialogic association of the midgrass prairie also varies the socioeconomic effects of grasshoppers discussed on pages 4-69 through 4-72. The AUM equivalent and average stocking rate of the mixed grass prairie ecosystem are near 2.5 and 0.4 respectively. Annual forage production on commonly encountered range sites in good condition are cited as being in the 1,700-1,800 pounds/acre range. These values are distinctly different than those of the short grass and

21-7 tall grass prairie. With the movement toward utilizing an IPM approach to "manage" grasshopper populations, inclusion of a mid-grass prairie management unit is necessary to insure sound biological and economical program decisions are made.

Appendix E, Glossary Page E-7

21-8 Suggest the definition of <u>rangeland</u> be expanded to include dry-land alfalfa that probably will not be cut for hay or harvested for seed. In dry years when heavy grasshopper pressure occurs in the plains region, these fields are often managed more as grasslands than croplands. This would be consistent with the 1986 control program criteria.

Sincerely,

Jimmy Krsnak

Jimmy Krsnak, Administrator
Plant Industry

JK/cj

22

PETER MEIKE & SONS, Inc.
SUSSEX ROUTE
Kaycee, Wyoming 82639

December 17, 1985

Charles H. Bare,
Staff Officer, PPD-APHIS-USDA
Federal Building, Room 663,
Hyattsville, MD 20782

Re: Draft EIS on the Rangeland Grasshopper Co-Operative Management Program, APHIS DEIS 86-1

I agree that an Integrated Pest Management Program is the most logical and long term successful approach to the grasshopper problem in the west. I must say, though, that the restrictions and regulations proposed in this EIS are perhaps severe enough to curtail the practical application of this approach and probably render it inneffective in any near term projects.

22-1 Grasshoppers have here to yet been unable to distinguish any difference between public and privately owned land and many of the restrictions in this document are certainly designed to eliminate any reasonable livestock management practices on the public lands. We need to be practical and recognize the public lands of the west as multiple use land. This thesis places more emphasis on possible damage to nature than on probable help for the livestock producer.

Restricted application within 500 feet of unlabeled crops, water, bees, etc. make practical application impossible. These are all items that should be handled on a case by case basis for each project. The bee management parts of this EIS really need to be addressed in a different manner. In a large part of the western rangelands, bees and beekeepers are guests of the landowner and even though we landowners are sympathetic to their needs, we feel that beeowners should not have such a strong position in the rules and regulations.

22-2 We should continue all efforts to discover new grasshopper controls, especially biological methods, but until better ways are established we should be allowed to pursue our battle against these pests with assistance from government agencies instead of restrictions.

I feel that this EIS should have encouraged research on new and improved pesticides. There should be an opportunity to test new practices

RCVD. ROSS 12-24-86

22-2 without having to follow these strict rules so closely. We are nearly unable to legally test any new products in an economical, cost effective program. We will still be in this same mess, and maybe worse, if some effort is not made to allow progress in this area.

I intend these remarks to be construed in a positive manner. I feel that we need assistance from APHIS-USDA rather than restrictions that effectively negate a very worthwhile aspect of the Federal Government. I am here to help in any way that I can.

Sincerely

Don Meike

23

THE STATE OF WYOMING

ED HERSCHLER
GOVERNOR

Wyoming Department of Agriculture

TELEPHONE: (307) 777-7321   CHEYENNE, WYOMING 82002-0100

JOHN ORTON, COMMISSIONER

December 16, 1986

Mr. Charles H. Bare
Staff Officer
USDA/APHIS, PPQ
Federal Bldg. Rm. 663
Hyattsville, MD 20782

Re: Rangeland Grasshopper Cooperative Management Program (Draft EIS-1987)

Following are some additional comments that were not included in the letter dated December 16, from the Wyoming Commissioner of Agriculture.

23-1 The Grasshopper Management Program should be included in an interpretative program, so persons using the area would understand what is going on and why.

23-2 Chapter 2, page 2-2; Cultural/mechanical methods. Alternative No. 1 used by itself does not meet the objectives of the Wyoming Weed and Pest Control Act and is not a viable alternative.

Alternative No. 2; Biological method used by itself would not meet the criteria of the Wyoming Weed and Pest Control Act.

23-3 Alternative No. 3; Chemical methods meet the objectives of the Wyoming Weed and Pest Control Act.

Alternative No. 4; Integrated pest management also meets the objective of the Wyoming Weed and Pest Control Act and is the preferred alternative.

23-4 Page 2-5, Aerial application, 4th paragraph, should include the use of Helicopters. It's believed in certain areas the use of helicopters would be beneficial.

23-5 Page 2-28, Table 2-1, No. 9. Do not apply any insecticide within 500 feet or directly to any crops for which it is not labeled. Any decision of this nature should be determined on site specified by the affected parties based on label recommendations. If we follow label directions the restriction stated is not needed.

"AGRICULTURE—the backbone of Wyoming"

December 16, 1986
Mr. Charles H. Bare
Page 2

23-6 Page 2-29, No. 6; Do not apply within 200 feet of any body of water. This is an unrealistic statement. This is what pesticide labels are for, by following label directions the above statement is not needed in this section. Please refer to your statement on page 2-36 which states in part; "The risk analysis indicates that there should be no adverse effects on water quality or aquatic environments from the use of acephate in grasshopper control in routine or accidental situations. Under normal operating conditions, most aquatic species would suffer no adverse effects from malathion spray".

23-7 Page 2-30, No. 13; Insert the word lactating so it reads; Do not allow lactating dairy animals to feed or graze on grass that has been treated with acephate. The label states; "Do not apply when lactating dairy cattle are present. Do not pasture or feed treated hay to lactating dairy cattle within 21 days after application".

23-8 Page 2-30, No. 14 d; Do not apply acephate, carbaryl, or malathion to any blooming crops or weeds or allow it to drift onto blooming crops and weeds if bees are visiting the area. This restriction only applies to carbaryl (Sevin 4-Oil). Why restrict the other two compounds?

23-9 Page 2-35, Table 2-6, Summary of environmental impact, Carbaryl spray; Here again it refers to 500-foot buffer between treated areas and bodies of water. The label states in part; "Do not apply directly to water and wetlands, except under the forest canopy. Do not apply when weather conditions favor drift from area treated." If label directions are followed, why do you need a 500-foot buffer?

23-10 It's suggested that you do a complete review of the pesticide labels on the three compounds listed in the EIS. The draft EIS should state that the EIS is only in place if (1) APHIS is contributing funding for the control program on private, state or federal land. (2) Only federal land is involved. The EIS indicates to the reader that the EIS applies to private and state lands regardless wheather APHIS cooperates or not in the control of grasshoppers.

Sincerely,

George F. Hittle

George F. Hittle
Weed & Pest Coordinator

GFH/dd

cc: Everett Johnson, President Wyoming Weed & Pest Council
John Orton, Commissioner of Agriculture

Files: USDA/APHIS

24

ARIZONA GAME & FISH DEPARTMENT

2222 West Greenway Road Phoenix, Arizona 85023 942-3000

December 22, 1986

Mr. Charles H. Bare, Staff Officer
PPQ-APHIS-USDA
Federal Building, Room 663
Hyattsville, Maryland 20782

RE: Draft Environmental Impact Statement-1987
Rangeland Grasshopper Cooperative
Management Program

Dear Mr. Bare:

The Arizona Game and Fish Department has reviewed the referenced draft programmatic environmental impact statement (EIS), and the following comments are provided for your consideration.

24-1 We are pleased to see the active effort to incorporate both biological control methods and range management techniques into the preferred Integrated Pest Management (IPM) alternative. The Arizona Game and Fish Department supports the preferred action of IPM for grasshopper management and control. We do strongly encourage, however, a program under IPM which assesses impacts on migratory bird species. Two species of concern in Arizona are Swainson's hawk and burrowing owl.

24-2 Regarding the draft EIS content, we are very disappointed in the descriptions of the affected environment (chapter 3) for the eight analysis regions, especially those regions within Arizona -- Plateau, Desert, and Mountain; these descriptions are superficial, at best. The Department fully realizes that in a generic document only general information and selected/typical species are mentioned; however, the information provided should be accurate and representative. We seriously doubt that readers of the draft EIS that are unfamiliar with the regions could recognize or identify with the flora and fauna of the area, particularly the aquatic life (fishes). Furthermore, we question whether the environmental consequences of a large scale pesticide application program can be evaluated within this document when the biological components and their role in the ecosystem have not been properly identified.

24-3 Overall, the DEIS appears to be based upon the analysis of the chemical properties and physiological effects of the various pesticides. Given that much of the species specific information is either incomplete or inaccurate, the Department must question the review and evaluation of the chemical and physiological aspects of this document.

24-4 Detailed considerations of the impacts of grasshoper control on threatened and endangered (T/E) species were to be accomplished by an EA developed for each state in the program. These findings were then to be "incorporated by reference into this EIS (page 4-1)." No specific references are made within this document. In addition, the Biological Assessment for Arizona (1986) was in itself inadequate. It did not consider all relevant species and left many issues unresolved. Therefore, "...those impacts (to T/E species) outlined only briefly here (in the DEIS) (page 4-1)" are misleading and inadequate to address a project with the potential of having serious adverse effects on local ecosystems, as well as numerous T/E species.

24-5 Since the draft EIS treats the biotic resources within analysis regions so superficially, the need to closely cooperate with the U.S. Fish and Wildlife Service and respective state wildlife agencies in developing local, site-specific EAS is significant. Therefore, the Department strongly urges local coordination with Regional U.S. Fish and Wildlife Service biologists and State wildlife agencies, for the purpose of developing local mitigation and identifying sensitive areas to wildlife and aquatic resources.

24-6 Additional comments by specific reference within the draft document are provided as an attachment.

The Department appreciates the opportunity to review and comment on the draft EIS, and we look forward to future consultation on local control/management programs to provide the most effective and long-term solution to the rangeland grasshopper problem.

Sincerely,

Duane L. Shroufe

Duane L. Shroufe
Acting Director

DLS:RKW:nlm
Attachment

Page 2-27, Table 2-1, Operational Procedures

24-7 The Department recommends adding State Wildlife Agency to the list of contacts under No. 4.

Further, we recommend amending No. 7.a., sentence 2, to read "...Fish and Wildlife Service <u>and State Wildlife Agency</u> ..." Also, No. 9 should be amended to <u>read the</u> same.

Chapter 3, Overview

24-8 The overview does not include any common fish species or any listings of occurrence for T/E fish species, nor does it indicate economic values of the fishery resources, which in Arizona alone were valued at over $239 million in 1980.

Page 3-27, Water Resources and Aquatic Life

24-9 The roundtail chub is <u>not</u> among the more common fish present. This species is <u>rare</u> enough to be included on the Threatened Native Wildlife in Arizona list.

24-10 The endangered and threatened reference should also include loach minnow, spikedace, humpback chub, squawfish, Gila and Yaqui topminnows, plus candidate species.

24-11 Major waters lying within the region include Lake Powell, San Carlos Lake, and the Colorado and Gila rivers.

Page 3-28, Terrestrial Wildlife

24-12 The desert bighorn sheep is a typical mammal of the desert region. The Sonoran pronghorn should be listed as a federally endangered species, and the masked bobwhite quail is a federally endangered species, not federally threatened.

Page 3-29, Water Quality, Quantity, and Aquatic Life

24-13 The fisheries of lakes Mead, Mohave, Havasu and all large reservoirs of interior Arizona, the Colorado, Salt, Verde, and Gila rivers, are also important, providing millions of dollars of sport fishing recreation annually, and should be appropriately addressed.

24-14 The sailfin molly is not an important fish species in the desert region; it is an exotic pet trade tropical fish that has established in some natural environments.

24-15 Endangered and threatened fish species that should be listed include the woundfin, bonytail chub, pupfish, and Gila topminnow.

Mr. Charles H. Bare   Attachment   December 22, 1986

Page 3-36, Terrestrial Wildlife

24-16 What are the "pronghorned" sheep? Are these bighorn sheep or pronghorn antelope?

Page 3-37, Water Resources and Aquatic Life

24-17 The cutthroat trout is not the only native trout. The Arizona and Gila trouts should also be listed, not only as native trout but also as federal T/E species.

24-18 Furthermore, virtually the entire salmonid fishery of Arizona lies written this region, and its recreational value cannot be over emphasized.

24-19 Common nongame fish of the region are listed as the longnose dace and the white sucker; however, neither is found in Arizona.

WYFB

December 18, 1986

The Wyoming Farm Bureau appreciates this oportunity to comment on the Rangeland Grasshopper Cooperative Management Program Draft Environmental Impact Statement.

The Wyoming Farm Bureau is a non-profit organization representing some 8,000 agriculture families or families which are supportive of agriculture. Many of these families have a significant interest in the manner which the U.S.D.A. carries out their rangeland grasshopper control program.

We believe the best alterntive for Wyoming would be the preferred alternative or alternative number three. This alternative is certainly the most flexible.

25-1 The "no action" alternative would not be acceptable for Wyoming agricultural producers and would result in substantial economic losses for these producers.

The "chemical control alternative" would accomplish the desired objectives for Wyoming but if a biological control is available which is more cost effective then it should not be excluded from consideration, as would be done under the "chemical control alternative".

Alternative number three or the "IPM Alternative" will allow for the use of biological controls as well as chemical controls, whichever is more effective. Economic considerations should be analyzed before a decision is made to use any of the controls listed in the IPM alternative.

There are some areas of concern in the IPM alternative which need to be addressed however.

On page 1-10 there is a paragraph which lists the minimum number of acres which will be considered for treatment under the APHIS program.

The requirements need to be modified or made more flexible for situations which have less than 10,000 acres of contiguous land.

25-2 The private landowners next to federal lands which do not have 10,000 contiguous acres are affected just as much as a private landowner next to a 10,000 acre block which will receive treatment. Rather than a flat minimum of 10,000 acres or more being used as the standard, perhaps a cost per acre or some other factor should be considered. The "hot spot" designation is certainly a beneficial aspect and should be left in the program.

25-3 Buffer zones, page 1-14. The restrictions for treatment around areas which have endangered species is not well written. Which endangered and threatened species are we talking about? Is this endangered species or threatened species even harmed by the control measure being used? If no significant harm can result to an endangered species or a threatened species by a control measure then why does a "buffer zone" even have to be established? Mitigation measures for private landowners harmed by non-treatment need to be resolved.

25-4 All of these questions and issues need to be resolved before consideration of buffer zones and non-treatment areas are considered.

Operational Procedures

25-5 The operational procedures listed in Table 2-1 have some disturbing problems which need to be changed before implementation.

The limitation on not conducting any operation within 1 mile of a peregrine falcon or bald eagle nesting site could eliminate vast areas for treatment, increase costs of treatment on the areas which have many nesting sites for peregrin falcons or bald eagles. Furthermore the information listed in the appendix (A-24) states that malathion is harmless to avian species in the dosages which will be applied to kill grasshoppers.

25-6 In appendix C (page 9) there is a diagram which indicates that aerial spraying will be restricted to a <u>10 mile</u> zone instead of the 1 mile zone mentioned in Table 2-1. The <u>information in</u> appendix A does not indicate the need to even have a one mile buffer zone for some insecticides.

25-7 The issue of mitigation for private landowners who would be harmed if such a "buffer zone" is established is not even considered. This restriction needs to be removed unless there is evidence to justify such an action and when or if such an action is taken to establish a "buffer zone" then mitigation to landowners needs to be considered.

25-8 Also the statement "follow other mitigation measures agreed upon in consultation with the Fish and Wildlife Service" needs to be defined. Unless it can be better defined this statement should be removed.

25-9 The restrictions on Carbaryl Bait (page 2-29) that will not allow placement of these baits within 200 feet of "any body of water" is not realistic. There are label directions which if followed should be adequate to cover any situation.

25-10 Also the restriction on not applying a bait withing 500 feet of any school or recreational facility is not needed. A recreational facility is not defined in this EIS. In light of recent developements on the national level by such groups as the President's Commission on Americans Outdoors there is no concrete definition of what a recreational facility is or may be. This particular restriction should be dropped from the restrictions. Labled directions should adequatly cover this situation.

25-11 Restrictions applied to Ultra Low Volume applications on page 2-30 do not appear to be warranted when the evidence presented in this Draft EIS is considered. The same arguments could also be used for this restriction as was used above on the Carbaryl bait restrictions.

25-12 The overall purpose of a grasshopper control program is to eliminate the grasshoppers. The EIS points out that the best method is to identify the infestations early and treat them so money and time can be saved. However in the restrictions listed in Table 2-1 "buffer zones" are created which allow massive amounts of money to be spent controlling grasshoppers on some areas but guarantees large areas of untreated land will be left so that a reinfestation can and will occur. The needs and desires of the U.S. Fish & Wildlife Service and the EPA should not be addressed in this EIS.

In a time of limited dollars, unrealistic and unnecessary restrictions need to be eliminated to ensure that the money spent for control achieves the best possible results.

Sincerely,

Ken Hamilton

Ken Hamilton
Research & Field Assistant

Oregon Department of Agriculture

635 CAPITOL STREET NE, SALEM, OREGON 97310-0110

VICTOR ATIYEH
GOVERNOR

January 6, 1987

Mr. Charles Bare, Staff Officer
PPQ, APHIS, USDA
6505 Belcrest, Federal Building, Room 663
HYATTSVILLE MD 20782

Dear Mr. Bare:

26-1 Our staff has reviewed the Draft Environmental Impact Statement - 1987 for the rangeland grasshopper cooperative management program. The discussion on environmental consequences seems to be very thorough, but we do have some concerns about certain other aspects of the document.

A. Project Limitations:

26-2

1. Page xx - Chemical Control Alternative and Page 2-28 - Operational Procedures, Item 9. "Do not apply any insecticide within 500 feet or directly to any crop for which it is not labeled, or to any crop for which no tolerance has been established, unless an exemption under Section 18 of FIFRA has been granted."

   It is unrealistic to designate a specific buffer width for these crops. To comply with this limitation it will be necessary to flag each of these fields, requiring more time and manpower than would normally be needed to be workable. We suggest that the procedures read, "crops not registered for treatment will be avoided by direct spray application or drift."

26-3

2. Page xxii, Chemical Control Activity, first sentence; page 2-29, item 6B; page 2-30, item 10.

   These items refer to 200 and 500 foot buffers around any bodies of water. This is too restrictive in that it means that stagnant ponds, barrow ditches, pools in intermittent streams, standing puddles, etc. must be buffered. Adhering to this requirement would greatly reduce the efficiency of the control program. A definition of what specific "bodies of water" must be buffered and the exclusion of those that are of little environmental consequence would be most helpful.

   In addition, grasshopper infestations are almost always most severe in the riparian habitat along streams. To require a 1,000 foot wide buffer along these waterways would greatly reduce the effectiveness of the control program.

26-3

To retain the 500 foot buffer around lakes and reservoirs seems appropriate but the riparian areas along streams should be treated according to the label, i.e., "avoid direct application to streams, etc..." This approach is supported by the Draft EIS itself (page 4-43 through page 4-45).

26-4

3. Page 4-30, item 14d, "Do not apply the chemical insecticides to any blooming crops or weeds, etc..."

   Blooming weeds occur throughout most treatment blocks in June and July. During grasshopper outbreaks the need to protect the land manager's investment is paramount. This restriction would greatly curtail the effectiveness of the control program and its value to the landowner. In order to protect bees foraging on wild blooming weeds, we recommend restricting application of insecticide to within a one mile radius around apiaries and two to four miles around leafcutter or alkali bee colonies used for pollinating alfalfa. Field program managers should be permitted the flexibility of working within these guidelines or of expanding the radius, depending on the local situation.

26-5

4. Page 2-25, line 35. "In sensitive areas, carbaryl baits or Nosema baits would be the method of choice regardless of timing."

   This criterion leaves the field program manager no option if treatment is required late in the season, at which time these baits would have little effectiveness. Nosema is not effective on mature grasshoppers and the effectiveness of carbaryl baits is greatly diminished. Furthermore, carbaryl bait is susceptible to runoff, and during a heavy rainstorm may contaminate the very area being protected. Malathion should be given favorable consideration in these situations since kill is immediate and the material dissipates in 4-5 days.

26-6

5. Page 2-29, item 5 advises that workers stay out of treated areas until insecticide has dried.

   Strict adherence to this request would eliminate the possibility of being able to adequately mark swath widths in certain spray blocks. In some instances staff members need to flag swath widths during the application process. The rewriting of this section with a recommendation that persons exposed to the application process should wear protective clothing or stay undercover during the application is suggested.

26-7

6. Page 4-21, paragraph 5, presumes that chemical insecticide is sprayed only once on a given portion of land in a given season.

   This concept is generally true, but does not allow for retreatment in case of washoff by rain. It is customary to retreat such areas and to include the retreatment cost in the overall program. This is indicated in the PPQ daily flight records and in work accomplishment reports. This section should be reworded to include the possibility of retreatment.

RCVD. FOSS 1-12-87

B. Nosema Treatment Option:

Regarding treatment by Nosema, it appears that more credit is given this treatment option than is warranted. Most of our areas of concern are summarized as follows:

26-8

1. Page xxi, paragraph 2, page 2-2, last paragraph. It is stated that Nosema is most effective in preventing outbreaks.

   This is not referenced and we do not know that Nosema will work in all situations. At best, this is speculation and should be indicated as such. It is stated also that 50% reduction in grasshopper populations can be obtained using Nosema. Again, there is no reference nor is there mention of the many instances in which Nosema caused no reduction in population levels. From personal experience, we know that there have been repeated tests in which Nosema caused little or no negative effect on the grasshopper population during the treatment season or in subsequent years. This should be addressed in order for uninformed readers to have a clear picture of the limitations of Nosema.

26-9

2. Page 4-76, last paragraph. Paragraph is misleading.

   Readers may reach the conclusion that Nosema treatments are cost-effective. Often they are not. At this point, given the high cost of Nosema applications plus the slow, ineffective results, this treatment alternative is almost cost-prohibitive.

26-10

3. Page 4-77, paragraph two, last sentence, gives the impression that if the costs of the bran bait application and Nosema are substantially reduced, these methods would become economical.

   This is not the case. If Nosema applications were comparable in cost to Malathion, the use of Nosema would still not be economical because of the poor results generally obtained. Presently, the use of Nosema is not a viable control option except that it appears to be environmentally safe. Nosema shall continue to be an integral part of the upcoming grasshopper IPM project, however. Perhaps the effectiveness of this biological agent can be greatly enhanced through predictive modeling, better timing, more viable spores, improved application techniques and attractants. At this point, the effectiveness of Nosema seems to be overstated in the Draft EIS.

C. Economic Impact: Pages 4-69, 4-72, 4-73

26-11

The growing need to protect our range resources for outdoor recreation have not been reviewed. It is becoming more and more apparent that ranchers who are unable to make ends meet financially with cattle operations are renting their property to hunters and fishermen. It is very important that they preserve high quality range and stream habitats in order to support healthy wildlife populations.

26-12

Thank you for giving our department the opportunity to review and comment on the Draft EIS, 1987, for rangeland grasshopper cooperative management programs. If you have questions or would like to discuss our comments further, please feel free to contact Mr. Dick Jackson 503/567-2249, our staff entomologist in charge of our rangeland grasshopper programs.

Sincerely,

B. L. Wright

Bill Wright, Administrator
Plant Division
(503) 378-3776

rcL24-.3K

27

STATE OF MONTANA
DEPARTMENT OF AGRICULTURE

OFFICE OF THE DIRECTOR
AGRICULTURE/LIVESTOCK BLDG.
CAPITOL STATION
HELENA, MONTANA 59620-0201

TELEPHONE:
AREA CODE 406
444-3144

TED SCHWINDEN
GOVERNOR

KEITH KELLY
DIRECTOR

December 31, 1986

Mr. Charles H. Bare
Staff Officer
PPQ-APHIS-USDA
Federal Building, Room 663
Hyattsville, MD 20782

Dear Mr. Bare:

Montana's Interagency Planning Task Force has reviewed the Rangeland Grasshopper Cooperative Management Program. Most of the agencies had no comments. The enclosed comments were made by the staff of the Montana Department of Agriculture's Environmental Management Division.

27-1 We support the preferred alternative, which emphasizes integrated pest management (IPM). The incorporation of alternative grasshopper management methods into the program may reduce grasshopper damage in the future.

We look forward to your consideration of our comments and your response to them in the final EIS. We appreciate your agency's attempts to control heavy grasshopper infestations in Montana and throughout the western United States.

Sincerely,

Keith Kelly
Director

la/JL/grass
Enclosure

An Affirmative Action/Equal Employment Opportunity Employer

RCVD. FOSS 1-2-8

27-1 Thank you for the opportunity to comment on the Rangeland Grasshopper Cooperative Management Program DEIS - 1987. The information was very complete and well organized. Many of our concerns with the 1986 Rangeland Grasshopper Cooperative Management Program were addressed in the 1987 DEIS. We support the preferred alternative, which emphasizes integrated pest management (IPM).

IPM Pilot Project. We generally approve the implementation of the IPM Pilot Project, described in the DEIS, to provide long-term management of grasshopper populations rather than only short-term control of grasshopper outbreaks. The long range planning effort should provide alternative ways to predict and control grasshopper infestations before extensive damage occurs.

27-2 The definition of IPM should be clarified. We suggest this alternative: IPM is the selection, integration and implementation of control tactics to maintain pest populations below economically damaging levels. The control tactics used in an IPM program are selected on the basis of the anticipated effects on economic, ecological and sociological factors associated with pest population suppression.

27-3 The IPM Pilot Project should not evaluate and compare the efficacy of proven products like carbaryl, malathion and acephate sprays. However, researchers should investigate different bait formulations containing products like dimethoate, chlorpyrifos and carbofuran as well as carbaryl and *Nosema locustae*. The IPM Pilot Project should not limit the testing of promising alternative products that do not yet meet all the criteria for full implementation.

27-4 Research plots for the study of IPM alternatives should meet the criteria established for operational treatment of rangeland. Grasshopper populations should meet or exceed the economic threshold. Treatments should be applied to the appropriate life stage of the population for optimum results with each product tested.

27-5 The DEIS should contain more information about in-flight encapsulation of malathion. Although encapsulation may be useful for drift control, encapsulated malathion may be very toxic to bees if the microcapsules are about the same size as pollen grains.

27-6 The IPM Pilot Project should work to define the relationship between range condition and damaging populations of grasshoppers. Researchers need to investigate the effects of improved grazing management and burning on populations of damaging grasshopper species. Hopefully, range management can eventually be integrated with other IPM techniques.

27-7 *Nosema locustae*. The DEIS states that the optimum grasshopper population density for the transmission of *Nosema*

27-7 _locustae_ is 15 to 22 grasshoppers per square yard. The DEIS should cite a reference for this information and indicate whether this figure applies to third instar nymphs or adults.

27-8 Large scale field tests of _Nosema_ _locustae_ for grasshopper control have shown inconsistent results, which are not easily quantified. This may be due to the use of _Nosema_ _locustae_ on grasshopper populations that are older than third or forth instar nymphs or on very heavy infestations. These experimental results probably represent a worst case response to the prevention efforts.

27-9 _Natural controls_. In addition to various natural factors that keep grasshopper populations from increasing at an enormous rate, the DEIS should recognize self regulating mechanisms in the population. Overcrowding leads to lower survivability and reproduction of grasshoppers.

27-10 _Economic thresholds_. Researchers should re-evaluate the economic threshold value of eight grasshoppers per square yard. According to the DEIS, this value was established in 1939 as the point where grasshoppers compete with livestock for forage. The economic threshold should consider the anticipated loss of forage production, the value of forage, the price of livestock products, and the availability of other feed supplies. The DEIS should state how these and other relevant factors like grasshopper and plant species composition, developmental stage of grasshoppers, and range condition will be used to modify the economic threshold.

27-11 The DEIS should indicate whether the costs per acre shown in Table 4-31 reflect the costs for an individual rancher or the costs of the entire grasshopper control program. The DEIS should also estimate the value of the forage protected and explain how this value was determined.

27-12 The DEIS should include treatment criteria used to protect crops from incipient infestations and should attempt to quantify benefits from crop protection and reduced soil erosion. It does not seem economically feasible to spend from $1.96 to $3.75 per acre to protect less than one animal-month of forage, which is leased for $1.35 per animal-month on Federal land, unless other less tangible benefits can be identified and quantified.

27-13 _Damaging species_. The grasshopper species that are listed on the map in Figure 3-7, the twostriped grasshopper (_Melanoplus bivittatus_), differential grasshopper (_M. differentialis_) and red legged grasshopper (_M. femurrubrum_), are minor rangeland pests in Montana. More serious pests include: the migratory grasshopper (_M. sanguinipes_), the white-whiskered grasshopper (_Ageneotettix deorum_), the bigheaded grasshopper (_Aulocara elliotti_), the striped slantfaced grasshopper (_Amphitornus coloradus_), the clearwinged grasshopper (_Camnula pellucida_), the Packard's grasshopper (_M. packardii_), and the tiny spur-throated grasshopper (_M. infantalis_).

27-14 _Grasshopper surveys_. The responsibilities of the summer scouts should be explained better in the DEIS. Since information about the species composition of grasshopper infestations is important in an IPM program, the scouts should be able to identify all life stages of the economically damaging grasshopper species on rangeland and cropland. To adequately train and supervise the scouts, the APHIS staff might consider hiring or obtaining the help of an entomologist familiar with grasshopper sampling and identification within each state.

27-15 Insecticide treatments should be evaluated to assess their effectiveness and to determine the need for retreatment. The DEIS should include the criteria used to decide if repeated applications are warranted. The DEIS states that control programs are generally not required at intervals of less than seven years after initial treatment, but the source of this information was not identified. Some areas like eastern Montana have required treatment for two consecutive years.

27-16 The DEIS did not consider the use of egg surveys at sentinel sites. This sampling technique is still used in Canada. The DEIS should explain why egg surveys have been abandoned in the United States.

27-17 _Water sampling_. Most pesticide residues dissappear rapidly from the water column. Residues from insecticide applications will probably not be detected in water samples unless the samples were taken immediately after the insecticide entered the water by spray drift or runoff. Insecticide residues are more likely to be present in sediment or in aquatic organisms than in water.

27-18 _Pesticide use_. The DEIS states that 10 to 12 million pounds of carbaryl, 9 to 11 million pounds of malathion, and 3 to 5 million pounds of acephate are used annually in 17 western states. The DEIS should explain how this information was obtained or how these figures were calculated.

27-19 _Safety_. The hazard, exposure and risk analysis for chemical controls was very thorough. People that handle pesticides should be aware of the danger from accidental spills. The risk of acute poisoning that may result from accidental spills is substantial for all products proposed for use, and the cancer risk from a spill of malathion also seems high. All field workers, mixers, loaders, and applicators must wear at least the minimum amount of protective clothing that is specified on the pesticide labeling for a particular product. Protective clothing requirements should be enforced by disciplinary action, if necessary.

People working with pesticides should have responsible supervision from licensed government or commercial applicators. All directions and precautions on the pesticide labeling should

be followed. Pesticide wastes and containers should be properly disposed of in approved facilities according to label directions.

Cholinesterase inhibition from carbamate insecticides like carbaryl is rapidly reversible because the cholinesterase is reactivated. However, organophosphates like malathion and acephate generally damage the cholinesterase enzyme so it no longer functions. Full recovery from organophosphate poisoning takes longer and depends on replacement of damaged cholinesterase in the body. Periodic monitoring of blood or plasma cholinesterase levels in workers that are routinely exposed to these insecticides is a wise precaution.

27-19 Drift. Pesticide application equipment should be properly calibrated to avoid application of excessive material and to ensure effective treatments. Operational procedures and recommended mitigating measures to reduce drift are generally good and should be implemented. Many aerial applicators operate only a few feet above the crop rather than at an altitude of 1 to 1.5 times the wingspan of the aircraft. The potential for drift is reduced if the altitude of release is lowered and application speed is slowed.

27-20 Wildlife. The indirect effects of large scale insecticide applications on birds should be investigated for both migratory and non-migratory species. It is reasonable to conclude that the treated area would constitute only a fraction of the total range of a species and that lowered survival and reproduction in the treated area would not generally be a threat to the species overall. However, this reasoning doesn't apply to species with a very limited habitat or to threatened or endangered species with few individuals remaining in the population. Buffer zones should be established around sensitive wildlife areas on a case-by-case basis, and these areas should either not be treated or be treated with less hazardous insecticides or formulations.

27-21 The DEIS should explain how direct mortality to wildlife would occur from no control as implied in Table 2-6. Also, most bait formulations present very little risk to non-target organisms. Bran bait has little or no food value for birds, so they would not likely injest significant quantities of bait flakes.

NEW MEXICO DEPARTMENT OF AGRICULTURE

OFFICE OF THE DIRECTOR/SECRETARY
Box 3189/Las Cruces, New Mexico 88003
Telephone (505) 646-3007

NEW MEXICO STATE UNIVERSITY

January 5, 1987 02A.10 grasshopper.letter

Mr. Charles H. Bare, Staff Officer
USDA APHIS-PPQ
Federal Building, Room 663
Hyattsville, Maryland 20782

Dear Mr. Bare:

This letter will serve to transmit the comments of the New Mexico Department of Agriculture (NMDA) on the Draft Environmental Impact Statement, 1987, Rangeland Grasshopper Cooperative Management Program.

This 1987 document represents a considerable improvement relative to previous grasshopper Environmental Impact Statements. The review of the toxicological literature concerning the various chemical insecticides is both extensive and readable. The established guidelines for avoidance of environmentally sensitive areas, including minimum buffer zone size and mitigation measures, appear to be adequate. The newly evidenced flexibility of APHIS with respect to the economics of rangeland grasshopper control is refreshing, as is the agency's recognition that each control program must be designed and managed on a case-by-case basis.

Over all, this Draft Environmental Impact Statement appears to be a well written, serious attempt by APHIS to address the legitimate environmental concerns implicit in rangeland grasshopper management.

Sincerely,

W.P. Stephens
William P. Stephens
Director/Secretary

WPS:ddl

cc: Barry Patterson, Division Director, Agricultural and Environmental Services

RCVD. FOSS

A

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JAN 1 4 1987

OFFICE OF
EXTERNAL AFFAIRS

Charles H. Bare, Staff Officer
PPQ-APHIS-USDA
Federal Building, Room 663
Hyattsville, MD 20782

Dear Mr. Bare:

A-1 As required under the National Environmental Policy Act (NEPA) and Section 309 of the Clean Air Act, the Environmental Protection Agency (EPA) has reviewed the Animal and Plant Health Inspection Service's (APHIS) 1987 Draft Environmental Impact Statement for the Rangeland Grasshopper Cooperative Management Program. APHIS' publication and EPA's review of this document is another positive step in the coordination between our agencies dating back to March 1986, when EPA gave APHIS 1986 grasshopper management DEIS, as supplemented, a category "3" (inadequate) rating. Subsequently, APHIS agreed to prepare a completely new programmatic EIS for 1987 and beyond. APHIS committed considerable resources to fulfilling this obligation. EPA commends APHIS for its diligence in preparing this EIS, and for its adoption of integrated pest management (IPM) as the preferred alternative for rangeland grasshopper management.

A-2 EPA wishes to reaffirm its support for an evolving grasshopper management program which will include greater emphasis on predictive modeling and a proactive approach that minimizes reliance on chemical pesticides. We urge APHIS to press ahead in the important work of testing and evaluating non-chemical control measures for use in an integrated grasshopper management program and to swiftly incorporate IPM methodologies judged feasible by the Technical Working Group into the program as a whole. We also continue to encourage adoption of the broader concept of range management as a strategic approach to long-term management of grasshoppers and other pests.

A-3 Ultimately, with the implementation of new methodologies, we envision APHIS' grasshopper management program to include the use of a risk-based decision tree to enable field personnel to select the least disruptive combination of cultural, physical, biological and chemical control measures for a given site. Contained within this matrix could be decision points related to plot size, pest population density, predator and parasite population density, weather parameters, site vigor or tolerance, presence or absence of specific avian, mammalian, reptilian, arthropod, or plant species in the treatment area, proximity to water or other critical habitats, nesting potential, and cost of treatment.

A-4 Despite our continuing discussions with APHIS, some concerns remain. Specifically, EPA feels that additional attention in the EIS needs to be given to the site-specific analyses that are to be tiered to the EIS, multiple chemical treatments, and the discussion given to endangered species. Based on our concerns, we have rated the 1987 programmatic grasshopper DEIS as EC-2 (environmental concerns -- insufficient information). Enclosed you will find our comments on these and other concerns.

A-5 In general, this EIS is a significant improvement over past submissions for APHIS programs. We believe that if APHIS adheres to the spirit of the program outlined in this document, then increasingly more sophisticated and environmentally conscientious grasshopper management concepts and methodologies shall continue to evolve and be implemented. If you have any questions on our comments, the rating, or continuing coordination in the development of the APHIS 1987 programmatic EIS, please call Paul Kaldjian of my staff at 475-8797.

Sincerely,

Richard E. Sanderson
Director
Office of Federal Activities

Enclosure

RCVD. MOSS 1/16/87

The Environmental Protection Agency's Comments
on the
Animal and Plant Health Inspection Service's 1987 DEIS
for the
Rangeland Grasshopper Cooperative Management Program

Discussion

A-6

° Of specific concern are several of the avian field studies. EPA is currently re-evaluating its view of what constitutes a valid field study and how to interpret the results vis-a-vis localized resident populations, migratory populations, and the population dynamics of entire species. Given the age of certain of the cited studies, it is probable that some of the studies relied upon in the EIS do not reflect current thought. In addition, these studies are probably inadequate to delineate avian effects resulting from such broad scale applications. Data is not available from pesticide use of the proposed magnitude and the extrapolation of information from small-scale studies may not be appropriate. Treatment blocks of 10,000 acres or more pose a significantly greater hazard than might be encountered under normal agricultural situations involving a few acres. Localized populations of birds such as passerines would be adversely impacted due to prey reduction and the limited range of their foraging behavior. This would be a particularly acute problem during nesting.

A-7

° APHIS needs to describe its procedures for preparing site-specific environmental assessments as it carries out its program. In numerous places in the DEIS (pp. XV, 2-2, 2-15, 2-18, 2-33, etc.), APHIS states that new methods developed for incorporation into its IPM alternative for controlling grasshoppers will be tiered to the EIS. However, the EIS makes scant reference to the need to prepare site-specific environmental assessments. We understand that APHIS is investigating the worth of preparing a generic site-specific EA to help expedite field operations during the grasshopper season; still, how environmental documentation will be tiered down from the EIS, and the information to be included in the EA, needs elaboration in the EIS.

A-8

° EPA is concerned that discussions of and mitigation procedures for endangered species are still incomplete. Even if endangered species will be evaluated in the tiered down environmental assessments, as implied in Table 2-1, Number 7, the EIS itself must present how endangered species will be treated and what mitigative options are available when endangered species are in the spray area. APHIS should identify the situations that exist when a chemical method under the IPM alternative is not an option due to potential adverse effects from the pesticides on endangered species.

A-9

° In our 1986 DEIS comment letter and the scoping letter for the 1987 EIS, EPA identified carbaryl, malathion, and acephate among the cluster of rangeland-use pesticides that pose risks to endangered species. The rangeland cluster is now completed. It is part of a proposed plan for the implementation of pesticide labeling to protect endangered species. For the rangeland cluster, enforceable label restrictions are expected to be in place prior to the 1988 growing season. Beginning in February, 1987, EPA will inform users of the restrictions to be imposed, and will encourage voluntary compliance during the interim period. As part of the plan, product labels will list the affected endangered species and the counties in which concerns exist, and refer to a "Rangeland Bulletin." Maps will be available to locate those areas where endangered species have been determined to be in jeopardy from certain pesticides used on rangeland. EPA is more than willing to discuss further the implications of the implementing plan for endangered species labeling on the EIS and APHIS' grasshopper program and to provide information as it becomes available.

A-10

° As we have stressed in the past, EPA believes it is necessary for APHIS to have a monitoring plan for evaluating its grasshopper management program. APHIS needs to provide criteria for determining the effectiveness, value, and success of the program. This evaluative, or overview, process is a way of determining whether the program is carried out as proposed, whether it accomplishes what was envisioned and whether it is worth doing again. Without relying solely on the IPM demonstration project for new data, there is, undoubtedly, much to be learned from APHIS' ongoing grasshopper control programs. This can only be done properly with a solid evaluation program.

A-11

° APHIS needs to give attention to the risks and cumulative effects of retreatment and/or multiple treatments. The risks may be such that APHIS should in no case retreat an area within at least four weeks of initial treatment. APHIS also needs to consider the pesticide programs of other agencies and organizations as it prepares its own. The cumulative impacts of all pesticides used in an area need to be addressed. For example, does APHIS anticipate operating its grasshopper management program in areas where the Forest Service is applying herbicides as part of a vegetation management or noxious weed program? This is an issue that must be addressed in each site-specific environmental assessment. If APHIS chooses not to retreat an area less than four weeks after the original treatment, it may, by the same token, choose to not assist in applying chemicals to an area under another pesticide program.

A-12

° The term "usefulness" needs clarification. It is stated in the EIS that, "... for a (control) method to be considered for incorporation into APHIS' cooperative program, it would have to be adequately tested, registered by EPA (if applicable), commercially available, and approved by the IPM Work Group as ready for transfer from research into field use.... Priorities will be assigned to those methods that have the most usefulness and that can be tested with the funds available." This last sentence is open to considerable interpretation. "Most usefulness" could be interpreted to connote "immediate results" which would eliminate many efficacious non-chemical control techniques.

A-13

° The comparative efficacy of chemical and non-chemical methods is discussed only very qualitatively. Additional quantitative evaluations would be very useful. Long-term benefits from current year treatments may be critical in evaluating the best control strategy.

A-14

° The comparison of costs presented on Table 4-32 (p. 4-75) regarding Nosema bran are questionable. The supplier of Nosema for the program indicated that, while the total cost was accurate, the material, support and application costs listed in the table were not. This table should be revised to reflect actual costs.

A-15

° The discussion of sociological impacts (pg. 4-77) is not complete without addressing consumer and regional impacts. The point that most social groups "support APHIS' efforts to control grasshopper infestations," followed by the statement that "some people are opposed to the introduction of chemicals into the human environment," is misleading. We suspect that it is less IPM and the need for grasshopper management than the broadscale application of pesticides that is the point of concern for many of the different social groups. APHIS should recognize that aesthetics and recreational values may be diminished during spraying. With the destruction of prey bases of non-target wildlife, local populations of non-target species may leave the area. Such a change in wildlife population would affect consumptive recreation, i.e., hunting, fishing, etc. We are glad to note that APHIS is "committed to working with the land managers... and the public before any control program begins (pg. 4-78)." EPA stresses the importance and value of consultation with all people having a valid interest in the use and management of the spray areas.

A-16

° The assessment of routine worker exposure is still incomplete. Exposure was assessed only for workers 500 feet from the spray area. The document failed to assess exposure to pilots or to mixer/loaders. Because of the large acreage that may be treated, the mixer/loaders and applicators have potential for significant exposure. Such exposure data are available in the published literature. Other possible sources for these data include the Forest Service of the U.S. Department of Agriculture and the registrants of the proposed insecticides. The Exposure Assessment Branch of EPA's Office of Pesticide Programs is willing to discuss this issue with APHIS personnel.

A-17

° Finally, the Agency understands the necessity of treating areas adjacent to cropland, since grasshoppers move from rangeland to cropland. That is to ask, will a remote grasshopper infestation, posing little or no threat to cropland or grazing, be allowed to run its natural course? Given our increased understanding of host plant tolerance to pest feeding damage over the past several years, it would be interesting to see the economics of treatment or lack of same, in the light of rangeland recovery from grasshopper attack. This would help substantiate the thought that periodic pruning is good for rangeland.

B

United States Department of the Interior

OFFICE OF ENVIRONMENTAL PROJECT REVIEW
WASHINGTON, D.C. 20240

TAKE PRIDE IN AMERICA

JAN 6 1987

In Reply Refer To:
ER-86/1355

Mr. Charles H. Bare
Staff Officer
PPQ-APHIS-USDA
Federal Building, Room 663
Hyattsville, Maryland 20782

Dear Mr. Bare:

B-1 We have reviewed the Rangeland Grasshopper Cooperative Management Program, 1987, draft environmental impact statement (DEIS) and consider it a better written, more informative document than previous program EIS's; however, there are some general, many specific, and program-related comments we feel still require some attention in the FEIS.

General Comments

The Operational Program

B-2 The use of Sevin 4-oil (Carbaryl) is one of the chemicals being considered for grasshopper control. Research from our Patuxent Wildlife Research Center indicates that petroleum applied to eggs in amounts of 5 ml or more drastically decreases survival and hatchability of mallard eggs (see Attachment 3). This impact is briefly mentioned in various sections of the text (e.g., page 4-26). However, further discussion is needed in regard to concentration of oil expected with the program under single or multiple applications. If concentrations in the range that impact eggs are expected, then a discussion of the reasoning behind the exclusion of other formulations (i.e., the bait formulation) should be included.

B-3 We feel that, based on information presented in this DEIS, carbaryl bait should be the chemical pesticide of choice in grasshopper projects which require the use of chemical pesticides. Carbaryl baits appear to cause nymphal and adult mortalities to the same degree of efficacy or better than liquid pesticides. Carbaryl baits also have an advantage in that their potential impact to non-target organisms will be less because a narrower range of organisms will be exposed to the material. The reduction of environmental risks attributable to the use of bran baits appears to outweigh the slight increase in per acre treatment costs.

B-4 Potentially Useful Biological Controls Omitted

Although we agree with the selection of IPM as the proposal, many potentially useful biological controls were excluded from the IPM Demonstration Project. The reasons for this should be discussed. Research should include the possible use of the various biological controls mentioned on pages 2-20 and 2-21 (Entomopox viruses (EPV's) and Entomophoga grylli (fungal pathogen)).

RCVD. FOSS 1-13

Endangered Species Act Coordination

B-5 A major concern with the DEIS is lack of adequate coordination under Section 7 of the Endangered Species Act of 1973, as amended. The DEIS states in a number of places (p. 2-27, Table 2-1; p. 4-1, par. 2; p. 4-38, par. 3; p. 5-2, last par.) that APHIS has prepared biological assessments for each of the States involved in the cooperative grasshopper control program. The final environmental impact statement (FEIS) should be clarified to state that assessments were prepared for the 1986 control program. The Fish and Wildlife Service (FWS) has not received any assessments for the 1987 control program.

B-6 It is understood that site specific endangered species concerns will be discussed in a separate Environmental Assessment, which will be produced far enough in advance to allow reasonable time for comments before the spray program begins.

A Long-Term Control Alternative Needed

B-7 While the proposal (IPM) incorporates the development of ways to predict and prevent outbreaks, this is still on a season-to-season basis. Chemical control is short range; prediction and subsequent treatment is season to season. More consideration of long-term control is needed; e.g., biological treatments. Additional research on the causes of grasshopper infestations may be necessary to aid in developing long-term control. Consideration also should be given to expanding the program to monitor long-term effects on wildlife.

The No Action Alternative

B-8 The DEIS does not completely examine the impacts of the "No Action" alternative. The possibility that "No Action" could lead to some beneficial results has not been discussed. In virtually all discussions in the DEIS of impacts of the "No Action" alternative, it is suggested that heavy infestations of grasshoppers (and Mormon crickets) would threaten or remove nearly all of the vegetation, cause plant growth to be retarded for several years, cause serious erosion problems, disturb soil organisms, reduce the abundance and diversity of wildlife, increase sedimentation of aquatic systems and reduce their productivity, and cause declines in rangeland productivity and livestock production. This anticipated level of impact for the "No Action" alternative, as described in these sections, may be somewhat overstated.

For example, a study by Ueckert and Hansen (1970) found that over 90 percent of the Mormon cricket's diet was forbs, fungi, and other anthropods; only about 6 percent were grasses. Preliminary results from a 2-year study in Dinosaur National Monument conducted by Colorado State University and the National Park Service indicate that Mormon crickets are nibblers and rarely eat a plant down to ground level. Secondly, it was observed that crickets prefer to eat broad leaf or weedy plants rather than range grasses. Arrowleaf balsamroot, lupine, locoweed, and groundsel seem to be the forbs most preferred. Lupine and locoweed are poisonous plants to livestock and cause millions of dollars of loss each year in the West. Finally, this same study has been unable to detect, in terms of weight, any significant consumption of range plants by Mormon crickets.

B-8 It is recommended that the effects described in the No Action alternative be either (1) moderated in the FEIS or (2) better substantiated with specific examples and more analysis.

Impacts on Wildlife Understated

B-9 We are concerned with the DEIS's lack of identification of species that may be affected by the proposed chemical spraying of rangeland habitat and the total absence of analysis of potential impacts on these species and proposed means to minimize or mitigate these effects. Throughout the DEIS the conclusion is drawn that there are no significant impacts on wildlife from use of the chemical pesticides. Several studies are cited. The FEIS should also consider other published reports which attribute impacts to wildlife. Seven studies are cited specifically for your attention (see Specific Comments) before concluding these analyses.

B-10 Potential Impacts on Health of Firefighters

In the discussions of impacts from the use of chemicals on human health, an additional consideration should be addressed. Many, if not most, of the potential treatment areas contain vegetation which is susceptible to fire. The FEIS should discuss any potential health impacts to firefighters who may inhale smoke containing combustion or volatilization products of malathion, carbaryl, diesel oil, or acephate.

Specific comments and references are covered in the attached material. Thank you for the opportunity to comment.

Sincerely,

Bruce Blanchard
Director

Attachments (4)

Attachment 1

Specific Comments

B-11 As a general rule, "Nosema" should be underlined throughout the document when it refers to the genus of the microsporidian pathogen rather than the name of a specific product. Specific studies are listed here which APHIS should consult before concluding its impact analyses on wildlife:

B-12

Finley, R.B., Jr. 1961. Direct and indirect effects of some insecticides on western wildlife. From: 40th Ann. Conf. W. Assoc. State Game and Fish Comms. 1960. pp. 121-129.

Grue, C.E., G.V.N. Powell and M.J. McChesney. 1982. Care of nestlings by wild female starlings exposed to organophosphate pesticide. J. Appl. Ecol. 19:327-335.

Grue, C.E., and B.K. Shipley. 1980. Interpreting population estimates of birds following pesticide applications - behavior of male starlings exposed to an organophosphate pesticide. In: C.J. Ralph and J.M. Scott (eds.) Estimating Numbers of Terrestrial Birds. Cooper Ornith. Soc. Studies in Avian Biology, No. 6.

McEwen, L.C. c. 1981. Review of grasshopper pesticides vs. rangeland, wildlife and habitat. In: Proceedings of the Wildlife-Livestock Relationships Symposium. Coeur d'Alene, ID. April 20-22, 1981. Univ. of Idaho. pp. 362-382.

McEwen, L.C. and L.R. DeWeese. c. 1981. Summary of 1981 field studies of acephate effects on rangeland wildlife. U.S. Fish and Wildlife Service, Ft. Collins, CO. 6 p. Unpubl.

Moulding, J.D. 1978. Effects of a low persistence insecticide on forest bird populations. The Auk 93:692-708.

Raisch, R.D. 1980. Proposed Cooperative Spruce Budworm Suppression Project, Maine, 1980. USDA, U.S. Forest Service. FS-80-01.

P. xix

B-13 It is stated that "Rangeland is devoted to the production of predominantly native forage that is harvested by grazing animals." It should be noted that recreation, wildlife, watershed, and other uses of rangeland are important and may, in some cases, be the major resource value for which rangelands are managed.

B-14 The same paragraph states that (western) rangelands produce most of the feeder livestock for the country. It is suggested that this statement should be substantiated or modified.

P. xxi

B-15 The statement that if grasshopper infestations are not controlled, plant growth could be retarded for several years does not appear to be substantiated by any research. This discussion does not take into account research done by Dyer and Bokhari (1976) that indicated grasshopper feeding stimulates the growth of range grasses in many cases.

B-16 Chemical Control Alternative. The DEIS fails to document the reduction of predator wildlife populations caused by the reduction of prey insect species where extensive territories are treated.

B-17 It is agreed that egg losses should be anticipated from the oil formulations due to the reasons stated in the report. In addition, however, oiled feathers of incubating adults would be an additional source of oil that would affect the entire egg surface as the eggs are rotated daily.

P. xxii

B-18 In the first paragraph under this heading, the statement is made that there should be no long-term effects to any species of aquatic organism from using carbaryl, acephate or malathion in grasshopper control operations. However, these three chemicals are highly toxic to aquatic organisms (Mayer and Ellersieck 1986). If these chemicals enter aquatic ecosystems, they may suppress aquatic invertebrates for up to a year. Their effects, therefore, are short term only if no additional grasshopper treatment or other spray project occurs the following year. In addition, acephate can further metabolize into a pesticide called methamidophos, which is acutely toxic to biota.

B-19 The 500-foot buffer zone between treated areas and bodies of water should be expanded in sensitive areas involving threatened and endangered species. The actual buffer zone should be contingent upon the biological opinion being developed by the U.S. Fish and Wildlife Service for the grasshopper control program.

B-20 The statement is made that accidental spills could cause neurotoxic effects that would be reversible. The document should also clarify that further exposure to an organophosphate pesticide before cholinesterase levels recover could cause even more severe effects.

P. xxiii

B-21 The statement is made that severe infestations could cause regional declines in rangeland productivity and livestock production, adversely affecting any dependent human communities. It may be more accurate to say that grasshopper infestations would adversely affect individual ranchers by reducing grass production and limiting specific livestock carrying capacities.

B-22 Other environmental effects. A summary of effects should be provided. The fact that over 70 million acres are expected to be treated within 5 years, and some areas 2-3 times annually, should be discussed.

P. 1-3

B-23 The discussion of Life History and Ecology of Grasshoppers and Mormon Crickets cites Metcalf and Flint (1939) in stating that Mormon crickets migrate in bands that often "consist of 100 to 500 individuals per square foot." It is suggested that this reference may be seriously misleading. In a research program at Dinosaur National monument, the National Park Service has occasionally observed 100 to 200 crickets per square yard in very early instars (i.e., prior to banding and migration). In monitoring of migrating bands, average band densities of over 30 individuals per square yard were seldom observed. This does not preclude isolated sites or small portions of a band that might reach densities of 100 crickets per square yard.

B-24 P. 1-4 Need for Control Activities: The last paragraph suggests that 23 percent of the dollar value of a typical annual forage crop on western rangelands is lost to grasshoppers. This statement needs to be clarified in the FEIS with the following information:

(a) The basic figures for such an estimate

(b) The dollar value based on typical animal use months

(c) The basis of comparison for the forage utilized

(d) The basis of comparison for annual forage production

It should be clarified whether or not the basis of comparison is competition between grasshoppers and cattle for the estimated forage that would constitute a sustained yield grazing situation. It is important that the figures be based on scientific research and that they are statistically valid. If not, they should be framed in the proper context to provide a valid basis for decisionmaking.

B-25 Additionally, this section needs modification because it suggests that 1977 was a typical treatment year; when, in fact, 1977 was actually a severe drought year through portions of the intermountain west.

Pp. 1-8 & 1-9

B-26 Maps are presented of areas predicted for grasshopper infestations of over 8 individuals per square yard in 1981 and 1986. It would be helpful to have companion maps which show the areas actually treated in those years.

P. 1-13

B-27 The document states that moribund wildlife may be collected following pesticide application. The FEIS should clarify under what circumstances such wildlife will not be collected and analyzed for residue analysis.

P. 2-3

B-28 The FEIS should document the benefits to grasshopper control provided by naturally occurring parasites and predators. By choosing chemical control, instantaneous reductions are promoted at the expense of a loss in natural controls.

P. 2-5

B-29 Paragraph 2: According to this section, ultra-low-volume (ULV) application involves the production of very small droplets which increase volatilization and spray drift; therefore, "proportionally more insecticide may travel off-target and may travel farther off-target than when using conventional application techniques." It is suggested the FEIS clarify whether buffer zones around water bodies and sensitive areas take this increased potential for spray drift into consideration.

P. 2-6

B-30 Paragraph 2: If retreatment is necessary, some sections may receive twice the dosage of pesticide. The DEIS does not include a description of the effect of doubling the dose to non-target organisms. This analysis should be provided.

B-31 Paragraph 3: It is stated that "areas where certain endangered or threatened species occur . . . and other sensitive areas are not treated." A description of the steps that will be taken to ensure that planes do not spray near peregrine eyries or over water bodies should be included in the FEIS.

P. 2-8

B-32 The discussion indicates that Sevin 4-oil (Carbaryl) is one of the chemicals being considered for grasshopper control. Research from the Service's Patuxent Wildlife Research Center indicates that petroleum applied to eggs in amounts of 5 ml or more drastically decreases survival and hatchability of mallard eggs (Attachment 3). This impact is briefly mentioned in various sections of the text (e.g., page 4-26). However, further discussion is needed in regard to concentration of oil expected under single or multiple applications. If concentrations in the range that impact eggs are expected, then a discussion of the reasoning behind the exclusion of other formulations (i.e., the bait formulation) should be included.

B-33 It is noted that the applicaton rate examined for carbaryl bait is 10 pounds of bait per acre containing 5 percent active ingredient. Page 2-9 describes the associated grasshopper mortality rates for such application. The DEIS also notes that other application rates will be examined and incorporated into use as they are determined, through research, to be effective. There are enough data available through ARS (and other) research on lower application rates to warrant immediate pursuit of EPA labels for those lower application rates. Furthermore, as noted by Onsager (1985, citation noted above), only a slight increase above normal in average daily mortality is necessary to hold population densities to low levels. Given these two considerations, it is suggested the FEIS give more emphasis to using lower application rates.

P. 2-10

B-34 There appear to be inconsistencies regarding the relative effects of the various compounds. For example, on page 2-10, the fourth paragraph states that malathion is low in toxicity to mammals and birds. However, the first paragraph on page 4-24 states that malathion is moderately toxic to mammals and moderately to slightly toxic to birds, while Table 2-6 (page 2-36) indicates that malathion is "slightly more toxic to wildlife than carbaryl." These inconsistencies should be clarified in the FEIS.

B-35 Page A-31 (paragraph 1) indicates that 4 ml of No. 2 fuel oil on eggs reduced hatching success to 18 percent. This does not correspond with the results in the attached paper. The discussion in the document should be reexamined.

P. 2-11

B-36 The FEIS should identify what antidrift additive will be used with the Orthene 75 s formulation.

P. 2-12

B-37 Paragraph 1: The DEIS states that acephate's half-life in water is relatively long, particularly at cool temperatures and low pH levels. At pH levels of about 7, half-life ranges from 16 to 47 days are given, while in the field, its half-life is said to be as low as 1 day to a few days. The field conditions under which this was determined should be described in the FEIS. The comparability of these locations to aquatic areas in the 17 Western States should also be discussed in the FEIS.

B-38 Paragraphs 1 and 2: More discussion is necessary on methamidiphos, a break-down product of acephate. The text states that this substance, itself a registered insecticide, shows "somewhat more toxicity than the parent compound." The document should be more specific; how much more toxic is methamidiphos and what exactly is its half-life? The DEIS provides no toxicity levels for this substance. The DEIS states most animal species recover from exposure to acephate in a relatively few days. The response of pregnant or nursing individuals, which are already under stress prior to spray application, should be discussed in the FEIS.

Pp. 2-14, 2-15, 2-20 & 2-25

B-39 The reasoning behind the selection of the oil and ULV formulation of carbaryl over the bait formulation is not clear. Migratory birds may be nesting over all portions of the western rangeland considered for treatment. The nesting of migratory birds should be included in environmental considerations. Since carbaryl bait is less detrimental to non-target organisms, its use would be preferred over that of the oil or ULV formulation. The FEIS should indicate where there are no environmental considerations such as migratory birds, and thus delineate the areas where the oil or ULV formulations of malathion and carbaryl may be used.

P. 2-17

B-40 Paragraph 2: The control efficacy data are presented as survival of grasshoppers, yet it is the feeding of those grasshoppers that is really of concern. Later in the paragraph it states that infected individuals do not feed as much as uninfected individuals. The efficacy of Nosema should be measured as the reduction in the loss of forage, not the number of grasshoppers surviving.

P. 2-20

B-41 This section briefly discusses the role of Entomophaga gryllias, an important fungal pathogen of grasshoppers and locusts. The implication of this section is that research on its effectiveness is being considered. It would be helpful for the FEIS to provide more detail on research on this fungal pathogen and other pathogens discussed in the next paragraph on Entomopox viruses.

P. 2-25

B-42 This paragraph states that "APHIS has entered into discussion with the FWS concerning the possibility of incorporating into the IPM pilot project a program for assessing any impacts that grasshopper control may have on migratory birds." This appears to refer, at least in part, to the monitoring program the Service has identified in past biological opinions as part of a reasonable and prudent alternative that should avoid jeopardy to peregrine falcons and listed fish species. This monitoring program, which included seven components, was to be carried out in conjunction with future spray programs along with certain buffer zones, in order to fully avoid jeopardy. The Fish and Wildlife Service has been approached by APHIS with the proposal to incorporate such a monitoring program into the IPM program, and the Service has indicated that this would be acceptable as long as an adequate number of sites were studied that would provide statistically sound information. In addition, the sites selected should be representative of the different habitat areas and biomes that in the 17 Western States.

In this paragraph it is implied that APHIS has not yet incorporated a monitoring program which meets the above criteria into the IPM program. If this is so, and until such a monitoring program is fully developed and accepted by the Service for the IPM program, a monitoring program should currently be considered as part of APHIS's normal grasshopper and Mormon cricket control program. Therefore, a monitoring program that meets all the components described by the Fish and Wildlife Service should be discussed and described fully in the FEIS in order to address the concerns the Service has noted previously for threatened and endangered species.

P. 2-26

B-43 It is assumed that the total area treated in the future will remain at levels similar to those in the past—with perhaps different control methods. This raises the question of why, with all this ongoing treatment, the situation regarding grasshopper infestation is not expected to change. The EIS would benefit from some attempt to explain the cyclic nature of grasshoppers and the occurrence of these cycles on other parts of the West.

P. 2-27ff table

B-44 Table 2-1, ALL METHODS, No. 7(a): This section should be revised to read as follows: "Formal and informal consultation with the U.S. Fish and Wildlife Service will be accomplished with the Washington Office or with the designated lead Region. Communications at the local level will be restricted to acquiring specific information regarding the status, distribution, or habitat needs of a species."

B-45 Table 2-1, ALL METHODS, No. 9: The second sentence should be revised to read as follows: "Additional measures identified by the U.S. Fish and Wildlife Service to avoid impact or jeopardy to listed or proposed species will be adopted and followed."

B-46 During past Section 7 consultation, the Fish and Wildlife Service has specified 10-mile no-spray buffer areas around peregrine falcon eyries and hack sites, within which bran bait or Nosema could be used, and as much as 2 1/2-mile no-spray buffers around bald eagle nests. In addition, a monitoring program addressing seven components has been included in several past biological opinions. If APHIS intends to incorporate these buffer zones or monitoring into their spraying program in response to past consultation, a statement to this effect be included in this section. As more information becomes available on specific eyries, hack sites, and eagle nests, as well as information from the monitoring program, these buffer zones may be revised.

P. 2-32

B-47 The Sevin XLR Plus formulation contains formaldehyde, an ingredient which itself is toxic and carcinogenic. Formaldehyde should be included in a hazard evaluation.

P. 3-1

B-48 The overview in Chapter 3 and the discussions of rangeland characteristics of the individual analysis regions provides a good general description of the physical and biological setting of the western grasslands. The document should also include a section on rangeland condition, particularly for each of the analysis regions.

B-49 The discussions on the federally listed threatened and endangered species are incomplete for every State included in the analyses.

Endangered species should at least be listed by reference to the pending biological assessments. In addition to this, most States have their own listing for threatened and endangered species. It is suggested State listed species should also be included in the analysis of effects.

P. 3-3

B-50 Table 3-1. It is not clear why 1.3 million acres were treated in Utah in 1985 whereas only 0.4 million acres were estimated to need treatment. It should be explained if the predictors are unreliable or if treatment that was conducted was more widespread than needed.

P. 3-11

B-51 Wildlife. This section only describes federally listed threatened or endangered birds found in the rangeland regions. Listed mammal species occurring in this region include the black-footed ferret (Mustela nigripes),gray bat (myotis grisescens), Indiana bat (Myotis sodalis), gray wolf (Canis lupus), grizzly bear (Ursus arctos horribilis), Utah prairie dog (Cynomys parvidens) and others. Listed fish species found in this region include the bonytail chub (Gila elegans), Colorado squawfish (Ptychocheilus lucius), greenback cutthroat trout (Salmo clarki stomias), humpback chub (Gila chpha), Lahontan cutthroat trout (Salmo clarki henshawi), woundfin minnow (Plagopterus argentissimus), Kendall warm springs dace (Rhinichtys osculus thermalis), and others. Reptiles and amphibians in the region include the desert tortoise (Gopherus agassizii), and Wyoming toad (Bufo hemiophrys baxteri).

P. 3-13

B-52 Paragraph 1: The piping plover is federally listed as a threatened species in the States of your proposed program, not endangered. The tree frog should be added to the list of common amphibians.

P. 3-13

B-53 Paragraph 1: It is unclear whether the last statement is a summary statement which applies to all of the eight analysis Regions or just to the southwest, California valley, etc. (page 3-20). If the latter is the case, a similar or modified statement alluding to surface water sources in grasshopper-infested areas also should be provided for each Region. Further, the water resource discussion appears to center on water availability for irrigation and livestock watering. However, surface water sources in the short and tall grass prairie regions, even though intermittent or ephemeral, are extremely important for wildlife and should be acknowledged.

B-54 There is a concern with the DEIS's lack of identification of species that may be affected by proposed chemical spraying of rangeland habitat and, therefore, the total absence of discussions on potential impacts/consequences on these species and means to minimize/ mitigate effects. The list of grassland birds on page 3-13 is incomplete. Please add, at a minimum, the following birds: Brewer's sparrow, ring-necked pheasant, chukar, Baird's sparrow, upland sandpiper, ferruginous hawk, golden eagle, Say's phoebe, lazuli bunting, gray fly-catcher, ash-throated flycatcher, mountain bluebird, western bluebird, rough-winged swallow, blackbilled magpie, common crow, common raven, rock wren, canyon wren, cactus wren, American robin, dark-eyed junco, European starling, Brewer's blackbird, brown-headed cowbird, rufous-sided towhee, green-tailed towhee, house finch, chipping sparrow, Cassin's finch, Srpague's pipit, McCowan's longspur, chestnut-sided longspur, lark bunting, Costa's hummingbird, black-chinned hummingbird, broad-tailed hummingbird.

B-55 Most of the grassland migratory birds are insectivorous in the breeding season. The proposed eradication of all arthropods within 10,000-acre or larger spray areas could result in indirect, if not direct, mortalities and further population declines of federally protected birds and their eggs and nestlings. Populations of many of the species

B-55 inhabiting rangelands that have been sprayed in the past and may be sprayed under proposed future programs are noticeably declining (Attachment 4). All migratory birds, their eggs and nests are protected against "taking or killing" under the Migratory Bird Treaty Act. Consequently, the FEIS should discuss in detail the likelihood of whether all practicable means will actually be adopted to avoid or minimize environmental harm from the selected alternative. If all means to minimize harm are not adopted, the reasons for not adopting them should be discussed in the FEIS. Impacts to species with declining populations should be discussed in light of the work by McEwen and others showing impacts of the spray program to migratory birds.

B-56 In reviewing the DEIS, it is not possible to determine what areas of the Western States have been sprayed in any given year. This information would be needed to correlate accurately chemical spraying to declining bird populations and should be included in the FEIS. Based on regional resource information and reviewing the Fish and Wildlife Service's Resource Publication 157, The Breeding Bird Survey: Its First Fifteen Years, 1965-1979, by Chandler S. Robbins, D. Bystrak, and P.H. Grissler, 1986, the following grassland birds show declining trends in the Western United States: Brewer's sparrow, lark bunting, loggerhead shrike, Swainson's hawk, Bendire's thrasher, curve-billed thrasher, rock wren, verdin, and pinon jay; and in Central United States: western meadowlark, dickcissel, and sharp-tailed grouse.

Page 3-16, 17

B-57 Under a separate subheading such as "Wilderness Resources" or "Special Areas," designated wilderness areas and wilderness study areas, should be identified as components of the environment requiring particular attention under the program. In the environmental analysis of this topic, potential impacts to wilderness areas should be described.

P. 3-22

B-58 Paragraph 1: Additional species that should be included in this list for the Tall-Grass Prairie Analysis Region as federally endangered or threatened are the bald eagle, peregrine falcon, and least tern. The blowout penstemon (Penstemon haydenii), was proposed for listing as an endangered plant species in Nebraska in the April 29, 1986, Federal Register.

P. 3-24

B-59 Paragraph 3: Other species that may occur in the Short-Grass Analysis Region include the endangered bald eagle, peregrine falcon, whooping crane, least tern, and Wyoming toad, the threatened piping plover, and the proposed blowout penstemon.

P. 3-26

B-60 Paragraph 5: Other threatened or endangered species that should be listed for the Plateau Analysis Region include the bald eagle, peregrine falcon, whooping crane, and several plant species.

P. 3-27

B-61 Paragraph 4: Threatened or endangered fish species that occur in the Plateau Analysis Region include the Colorado squawfish, humpback chub, bonytail chub, and woundfin. The Virgin River chub has been proposed for listing as endangered.

B-F Paragraph 1: Other endangered or threatened species that should be included in this list for the Great Basin Analysis Region include the bald eagle, peregrine falcon, and whooping crane.

P. 3-30

B-63 The narrative on Terrestrial Wildlife, Great Basin should list the sage grouse, a candidate species for Federal listing as threatened or endangered in Oregon and Washington. This is especially relevant since the sage grouse is referred to as a representative species used in the exposure analysis (page 4-17). It is not timely to wait for a site-specific EA to discuss possible impacts to the habitat of this or other candidate species, as indicated in Table 2-1, page 2-27.

P. 3-31

B-64 Last paragraph: Endangered or threatened fish species in the Great Basin Analysis Region include the June sucker and Lahontan cutthroat trout. The meadowlark should be included in the list of rangeland species.

P. 3-36

B-65 Paragraph 2: The endangered bald eagle and peregrine falcon also occur within the Mountain Analysis Region.

P. 3-38

B-66 Paragraph 1: Erosion and fire are problems not only in the southern-most mountain regions, but throughout the mountain region.

P. 4-4

B-67 Giles (1970) found a pronounced reduction of arthropods on his study areas. Populations of some insects bounced back, but study design did not exclude immigration, so the conclusion that malathion had no effect cannot be drawn.

P. 4-6

B-68 In this section, the document provides a lot of discussion in relating erosion to grasshopper infestation. Erosion caused by other factors, including cattle overgrazing, should be presented for comparison.

P. 4-9

B-69 Potential Impacts on Endangered or Threatened Plant Species. This section discusses the concern that endangered plant species may be severely impacted by a reduction of seed production due to the loss of insect pollination. It is indicated that the impact will be mitigated because operational procedures have been developed to protect commercial beekeepers. However, it is unlikely that beekeepers will maintain bee colonies in locations that contain threatened or endangered plants which are often found in very remote areas of the west. The primary concern should be with the many native insect pollinators that will be killed along with the grasshoppers during the spray program. Loss of these insects may indeed have an impact to listed plants due to the reduction in seed production. This loss should be analyzed.

P. 4-17

B-70 It is recommended that "beef cow," listed as a wildlife species, be replaced with "mule deer" in the section on wildlife exposures. An evaluation of the beef cow in addition to mule deer is also appropriate.

Pp. 4-23 & 4-51

B-71
B-72
B-73
B-74
B-75
B-76
B-77
B-78
The application of this analysis to an existing situation is questionable. The results of the risk analysis are considered conservative by the document. The analysis only suggests there will be no direct massive mortalities. The analysis does not consider the behavioral effects on nesting birds; does not consider environmental stresses that accompany nesting; assumes that dosages are known; and does not consider all sources of exposure (e.g., eggs will not only receive direct exposure in some cases, but may be further contaminated by contaminants on the incubating bird). Any alteration of behavior that would keep incubating birds off nests for approximately 2 hours in cold, wet weather will cause reproductive losses. Traveling miles to find food for growing young will also cause reproductive losses. The document does not use the risk criterion for humans because of health reasons. However, while it is assumed that 1/5 the LD50 is safe, EPA identifies this level as a significant risk. For large areas, analysis should focus on No-Observed Effect Level of dosage rather that then the 1/5 LD50.

B-79
B-80
B-81
B-82
The model appears to be complex and poorly referenced based on a review of the calculations. It should be explained why the American kestrel's exposure was calculated on ingestion only. Also, what was the rationale for stipulating that 39 percent of its diet was grasshoppers when during a severe outbreak perhaps nearly 100 percent of the diet might be debilitated grasshoppers? Similarly, it appeared that the weight vs. surface area ratio was considered the same for birds and mammals. The surface area for birds should contain estimates of surface area of plumage, since birds will preen off pesticides adhering to feathers. The VCP, PBG, etc., should be explained, referenced, and field verified. These appear to be untested and unsuitable for defending the spray program.

P. 4-24

B-83 Henderson, 1967: not in reference cited. McEwen et al., 1972: not in reference cited. Sinclair, 1968: not in references cited. USDI, 1963: not in references cited.

B-84 Wildlife. Impacts of Chemical Grasshopper Control Methods. Recent experimental work and field observations have observed that the toxicity of a number of organophosphorus insecticides (e.g., dicrotophos, malathion, parathion, temephos) to quail, raptors, songbirds and waterfowl is increased by extreme temperatures (Rattner 1985). The acute toxicity of these chemicals is markedly increased at both high and low temperatures, at times up to two-fold. It has also been observed that the ability of birds to tolerate cold temperatures may also be reduced by exposure to organophosphorus insecticides. Extreme temperature variations are common throughout the west and may expose birds to life-threatening situations due to the large-scale programs of APHIS. The FEIS should either state that pesticides will not be sprayed at extremes of temperature or factor temperature into the risk assessment.

B-85 The last paragraph on this page states that "field studies indicate that significant effects on mammals are unlikely as a result of grasshopper control with carbaryl." Lavigne and Pfadt (1966) found that populations of the northern grasshopper mouse (Onychomys leucogaster articeps) increased with rising grasshopper populations and dropped after grasshoppers were controlled. The document should be corrected as appropriate.

P. 4-25

B-86 The discussion of effects on birds should include the many studies which show adverse impacts. For instance, Moulding (1976) reported significant declines in bird population in areas treated with carbaryl at 1 pound/acre. Opportunistic feeding outside spray area would not be an option for grassland birds in spray areas of over 10,000 acres. Similar results have been shown for birds, presumably because of food chain disruption.

B-87 Reduced reproduction success has also been reported in quail and pheasant, at rates expected to prevail as a result of this program. Decreased chick survival and weight are also reported as a result of exposure to carbaryl.

P. 4-27

B-88 The exposure analysis is based on the highest doses that an individual organism could experience under actual spraying conditions. A review of the detailed methodology (Appendix B) and Tables 4-7 to 4-10 indicates that this single event was used to compare the estimated dose with 1/5 LD50 and LD50 references. Based on the discussion of the environmental fate of the chemicals (half-lives) and bioaccumulation potential (which is apparently low), this may be a valid representation. However, whether or not this actually represents a valid condition if an organism (e.g., a bird) continues to daily ingest the chemical (even if this becomes less and less concentrated) is another matter, particularly if the animal is in a weakened state due to the initial heavy dose. Also, young-of-the-year birds feeding almost exclusively on insects could demonstrate a different exposure result than other age birds feeding on the variety of items used in the exposure analysis. The FEIS should include a cumulative analysis [similar to that used for calculating human dosages (page B-29)] for representative wildlife, including young-of-the-year birds. Further, this analysis also should include an example where two to three treatments may occur within a 1-year period, as explained on page 4-49, last paragraph. Since the program can include up to 20 percent cropland, this could be an important concern if the cropland attracts geese or other waterfowl.

P. 4-32

B-89 The last paragraph should read: "Part of the lower Snake River is designated as a Wild and Scenic River. Part of the Middle Snake River in southern Idaho includes the Bureau of Land Management's Birds of Prey Area, where the world's largest known nesting population of prairie falcons exists. In the past, lands within the Birds of Prey Area have been treated by APHIS to control grasshoppers. The Desert National Wildlife Refuge...."

P. 4-33

B-90 The last paragraph states that in any given treatment season, only a fraction (less than 1 percent) of the total rangeland in a region is likely to be sprayed for grasshopper control. This statement is contradicted by Table 3-1 which shows that in 1985, 4 percent of Wyoming, 2 percent of Utah and 12 percent of Idaho were treated for grasshoppers.

P. 4-36

B-91 In the risk analysis for carbaryl and diesel and petroleum oils, a separate risk analysis is done for each compound (Tables 4-8 and 4-9). The document should also provide a risk analysis of an additive or synergistic effect of these compounds if areas will be sprayed more than once during the treatment season.

Pp. 4-38, & 4-39

B-92 The document acknowledges that grasshopper control programs pose a risk to insectivorous birds and that bird populations will likely decrease in treatment areas. The selection of a one mile no-treatment zone around peregrine falcon nest sites therefore discounts the generally accepted 15 mile hunting radius required to support rearing chicks. It is recommended that this one mile no-treatment zone be made flexible on a case-by-case basis depending upon the habitat surrounding individual eyries. Also, selection of a no-treatment zone distance should be kept open until the biological opinion is completed by the FWS, Region 6.

P. 4-39

B-93 The statement on page 4-39 that "Field studies indicate that there have been no significant impacts on wildlife in areas treated with chemicals at application rates similar to those proposed for the current program" should be revised to reflect the literature which shows adverse impacts.

B-94 Paragraph 2: As indicated above, the FWS has identified, during Section 7 consultation on APHIS's 1986 grasshopper control program, the need for 10-mile no-spray buffers around peregrine falcon eyries and hack sites, and as much as 2 1/2-mile no-spray buffers around eagle nests. The FEIS should note these buffers.

B-95 Paragraph 4: The draft operational procedures (page 2-30) prohibits dairy animals from feeding on acephate-treated grass hay. On page 4-39, the document should discuss a similar threat that could exist to wild ungulates. If the milk of dairy cattle may be

B-95 contaminated when acephate-treated hay is eaten, the milk of deer, big horn sheep, and antelope may be likewise contaminated when their forage is sprayed.

P. 4-40

B-96 Burrowing owls may be impacted through dermal contact, inhalation and through loss or contamination of food sources. Reports exist of unsuccessful nesting of burrowing owls during the peak of the 1985 spray effort. Typically, these birds will not be highly mobile, especially while nesting, so loss of eggs, young and adults should be expected. The same situation for passerine birds exists. These birds are not going to be successful trespassing on adjacent pairs territories especially if expected to carry food for young several miles each trip from an unsprayed area (10,000 acres away). This should be noted in the document.

P. 4-41

B-97 Paragraph 1: The DEIS states that operational procedures call for a 500-foot buffer between treated areas and bodies of water and, "thus under normal operating conditions, the chemicals would reach water only through spray drift." On page 4-43, paragraph 2, it is stated that malathion residues were found in water adjacent to a treatment area in Idaho. Treatment with chemical controls results in a reduction in aquatic insect populations. Because it is impossible to rule out an effect, the use of a 500-foot buffer zone therefore would require a Formal Section 7 consultation any time a spray project was within 500 feet of the habitat of an aquatic endangered species. To avoid this continual consultation process, it is recommended adoption of a larger aquatic buffer zone where the habitat of a federally listed threatened or endangered species is involved. The document should use the Spray Drift Model, described in Appendix B (Table B-4), to develop a deposition rate in water with a correlated distance that produces a residue level less than 1/10 the LC50 for aquatic invertebrates. This distance should then be used as the buffer zone distance.

P. 4-43

B-98 The conditions and concentrations under which pesticides have been implicated in causing lordosis should be discussed in the FEIS. The defect has been noted in fishes in the Green and Yampa Rivers in recent years.

P. 4-44

B-99 Table 4.12. It should be discussed whether or not Sevin 4-oil concentrates the toxic material on the surface of water or whether it rapidly separates and disperses throughout the pond as indicated. One of the purposes of adding oil was to keep water from diluting and dispensing the active ingredient. The table should indicate ppb, not ppm.

P. 4-44

B-100 Many of the tables would be improved with more complete captions. As an example, Table 4-13 deals with accidental scenarios. The third column deals with the jettisoning of a total load into a reservoir. There is no indication of the volume of the planes' tanks,

B-100 concentration in the planes' tanks, or the volume of the reservoir. Columns four and five dealing with runoff have similar flaws. Some of this information can be found in the text. A complete table would provide better information and allow for a better review.

P. 4-49

B-101 Last paragraph: It is difficult to determine from discussions throughout the DEIS if the 500-foot buffer zone around water bodies includes wetlands. Wetlands should be included within this category, and a statement to this effect should be in the FEIS. For example, the FEIS should indicate if the 500-foot buffer requirement applies to small isolated stock ponds and if ephemeral wetlands, including wet meadows, are considered to be water bodies and subject to the 500-foot buffer requirement. In this regard, it is stated (page 5-4) that "none of the APHIS grasshopper and Mormon cricket control activities on rangelands should directly affect any wetlands." However, spraying wet meadows, coulee areas with hydric soils and wetland vegetation (with or without open water) would directly affect these habitats if they are not considered to be wetlands (and the buffers are not observed). Rangelands in the short grass and tall grass region are not necessarily broad, uniform, flat expanses of land, but often include broken or undulating terrain, such as draws and coulees. These often provide the only dense cover (shrubs and sometimes scattered trees) and small water sources for wildlife. Consequently, wildlife often concentrate in these areas. If such areas are sprayed (and considering the half-lives of carbaryl, carbaryl bait, and acephate in areas with such condtions), exposure of signi-

B-102 ficant numbers of wildlife would appear to be likely. Although the document presents generic scenarios, it does not appear to account for or explain what the impacts would be where the bulk of the wildlife population for a given geographical area may be concentrated in a few "critical areas," such as wooded draws, and so forth. Although details of individual spraying programs (supplements to the programmatic) may address specific habitats, we believe such a scenario also should be presented in the programmatic.

P. 4-69

B-103 Analysis concerning potential impacts to wilderness values in designated wilderness and wilderness study areas should be provided. Actions from permitted control measures, particularly those involving mechanized equipment, may result in surface disturbance or other negative impact.

P. 5-3

B-104 Paragraph 1: In the sixth line, the word "mitigation" should be removed from the sentence. In addition, the last sentence of this paragraph should be removed completely.

Program-related Comments

B-105 The IPM Demonstration Project (Project) should be helpful in testing the efficacy of biological controls. However, many potentially useful biological controls were excluded from the Project. The reasons for this exclusion should be discussed in the FEIS and research to expand the tools of integrated pest management beyond the three chemicals and one protozoan parasite proposed for use in the preferred alternative should be included in the Project. Research should include the possible use of the various biological controls mentioned on pages 2-20 and 2-21 (Entomopox viruses (EPV's) and *Entomophaga grylli* (fungal pathogen)).

B-106 A problem with the incorporation of new biological control technologies has been the resistance of spray contractors and field personnel to the changing of spray rigs, field procedures, and pesticides. In light of the stated primary aim of prevention of outbreaks and development of alternative methods of grasshopper control that minimize the use of chemicals (page xvi), the FEIS could discuss the steps that will be taken to implement the use of biological controls. An educational program for spray contractors and field personnel and a policy regarding the use of *Nosema* and other biological controls when landowners or land management agencies request them is suggested.

B-107 Beginning on page xiii and continuing through the document, the DEIS identifies 8 adult grasshoppers per square yard as an economic threshold. The DEIS notes other factors which affect the degree to which an infestation is economic and further notes that control programs are usually not conducted unless population densities are 2-3 times greater. It is suggested that it would be appropriate for APHIS to conduct a series of studies which could more accurately define economic thresholds under a series of general conditions based on species or species complexes present, food habits, vegetation complexes, stocking by domestic livestock, etc. This research should also include Mormon crickets. There has been little or no identifiable range damage by Mormon crickets in northwest Colorado, for example, even at densities of 15-20/square yard in recent years. Therefore, the economic threshold for Mormon crickets may be higher than the figure cited for grasshoppers.

B-108 The discussion on Potential Future Components of the IPM Alternative (pg. xvii) should be expanded to include a discussion of alternatives for treating "incipient" population explosions since only a slight increase in mortality in these situations could maintain a population at levels below the economic threshold.

B-109 Relative to this section and other sections throughout the DEIS, it is suggested that less restrictive criteria be adopted for incorporating new non-chemical methods into the cooperative program, at least to the extent of conducting field tests beyond those of the formal IPM Demonstration Program. An example of another method which should be investigated on a field trial basis is use of the (as yet unnamed) microsporidian pathogen identified in Mormon crickets in northwest Colorado by Chuck MacVean and John Capinera of Colorado State University. Initial results from lab tests, together with observed levels of infestation in field populations, suggest that this pathogen may be quite effective in controlling Mormon cricket populations.

B-110 In Appendix C (pg. 113) and elsewhere in the document, the DEIS discusses monitoring programs. These monitoring programs appear to provide only cursory examinations of soils, water and target species over a very short period of time (less than 24 hours after treatment). This may be an inadequate monitoring program. Some of the areas of greatest concern (and where there is sometimes conflicting or inconclusive literature) relate to long-term and short-term impacts of control programs on non-target organisms (for example, see Appendix D). It is suggested the program be expanded to indicate that monitoring of non-target insects and vertebrates, particularly endangered species, is part of the APHIS IPM Demonstration Project and that long-term monitoring of wildlife, soils, water, etc., will also be included.

B-111 The discussion on pages 1-5 through 1-7 describes the types of surveys that APHIS uses to assess potential grasshopper problems. These surveys (especially nymphal surveys) were apparently not conducted with enough intensity or frequency to determine daily mortality rates. Information presented by ARS at the interagency IPM Technical Group meeting in Bozeman, MT, in June 1985, indicated that a small percentage change in average daily mortality of nymphs can result in significantly different population levels of adults (i.e., a small increase in average daily mortality may hold a population below an economic threshold). Please see also: Onsager, J.A. 1985. An ecological basis for prudent control of grasshoppers in the western United States. Proc. 3rd Triennial Mtg., Pan Amer. Acrid. Soc., July 5-10, 1981. It would seem reasonable, with an integrated pest management approach, to monitor nymphal populations closely enough to determine with more certainty whether or not treatment is actually warranted. It is suggested that nymphal surveys be restructured to provide for this improved level of certainty.

B-112 The APHIS program (p. 1-13,14) that monitors the effects of the spray program on threatened and endangered species, migratory birds and aquatic organisms will operate in conjunction with the IPM project. It should be stated that where it is not possible to monitor adequately the IPM Project because of experimental design limitations, this function will be taken over by the operational spraying program.

B-113 In the first paragraph (p. 1-14) the document states that a special monitoring study will be conducted for sensitive areas. It should be pointed out that the selection of the sensitive areas, and subsequently any monitoring, should be based upon the biological opinion for threatened and endangered species that will be coordinated and prepared by Region 6 of the U.S. Fish and Wildlife Service, Department of the Interior. The individual State programs will also dictate where treatments and sensitive areas will coincide.

B-114 In biological opinions issued on June 2, July 3, and August 8, 1986, the FWS identified a monitoring plan which consisted of seven components. This monitoring plan was identified as part of a reasonable and prudent alternative that would offset jeopardy to peregrine falcons and listed fish species from APHIS' 1986 grasshopper and Mormon cricket control programs. Before APHIS could carry out any 1986 spraying operations in the vicinity of these species, they were expected to develop a monitoring program that would meet all seven components listed in the biological opinions. Although APHIS subsequently presented a monitoring plan to the FWS, it did not meet these seven components, and the FWS informed APHIS that it was not acceptable and would not avoid jeopardy.

B-114 However, the "special monitoring project" mentioned in this paragraph appears to refer to the monitoring program that earlier was reviewed by the FWS and rejected as unacceptable. Simply determining whether spray enters a "no treatment" or "no aerial treatment" buffer zone established for certain endangered and threatened species is no more than APHIS's normal monitoring procedures. The monitoring program identified by the FWS is intended to investigate the abundance of prey species of peregrine falcons, the levels of carbaryl in these prey species, and the levels of acetycholinesterase in a species related to the peregrine, both before and after spraying. In regard to aquatic species, APHIS was expected to determine the levels of carbaryl and malathion in water near sprayed areas, the level of acetylcholinesterase in fish near treated and untreated areas, the incidence of lordosis in larval fishes, and the abundance of aquatic macroinvertebrates in the Green and Yampa Rivers.

The third paragraph on page 1-14 makes reference to monitoring which "could be used to determine specific impacts on endangered species and migratory birds." More specific information to this effect should be included in the FEIS, including any basic research designs that have been developed to date. In addition, the threatened or endangered species associated with the monitoring program should be identified.

B-115 Based on information presented in this DEIS, pages 2-8 to 2-12, carbaryl bait should be the chemical pesticide of choice in grasshopper projects which require the use of chemical pesticides. Carbaryl baits seem to cause nymphal and adult mortalities to the same degree of efficacy or better than liquid pesticides. Carbaryl baits also have an advantage in that their potential impact to non-target organisms will be less because a narrower range of organisms will be exposed to the material. The reduction of environmental risks attributable to the use of bran baits appear to outweigh the slight increase in per acre treatment costs (e.g., Table 4-75).

RESPONSES

Letter 1

Standard operational procedures require that APHIS not spray when rain is falling or imminent. However, there are infrequent occasions where unforeseen rain events occur over portions of a large treatment block shortly after spraying. Because of concerns regarding the possibility of risk to humans and the environment, APHIS will not respray in these instances until adequate analysis has been conducted. However, APHIS can respray with carbaryl or malathion as needed after 4 weeks, as discussed and analyzed in the sections on multiple applications in the aquatic, wildlife, and human health impacts analyses in chapter 4 of the EIS.

Letter 2

2-1 This operational procedure is a label requirement. It has been clarified in table 2-1 based on the EPA interpretation that the restriction applies to times when commercial bees are in the vicinity of blooming crops or weeds. "Blooming" crops or weeds means that enough of the plants are in bloom to attract domestic pollinators. Given the notification requirements and other commercial bee protection measures outlined in procedures 15a-c (formerly 14a-c), the restriction of 15d (formerly 14d), as revised, should not prevent effective spraying programs.

2-2 The studies mentioned by Wright were conducted in the following locations: (1) between Billings and Hardin, Montana; (2) in Sheridan, Wyoming; (3) in San Carlos, Arizona; and (4) in Platte County, Wyoming (several locations). Note that the text to which you refer has been revised to reference Onsager (1986a), which describes two field studies where infestations treated with Nosema were abated over 1 or more years.

Letter 3

3-1 The operational procedures have been clarified to indicate that the 500-foot buffer zone for ULV sprays and the 200-foot buffer zone for carbaryl bait apply to bodies of water supporting higher aquatic life; these specifically include reservoirs, lakes, ponds, pools left by seasonal streams, springs, wetlands, and perennial streams or rivers. Stock watering tanks or pits, ephemeral ponds or puddles created by rainstorms, and stagnant pools would not require these buffer zones, as they would not support higher aquatic life during the treatment season.

3-2 See response 2-1.

Letter 4

4-1 Nosema is best used in a preventive approach because it is slower to act than chemicals. It is most effective when introduced at early stages of infestation (by the third nymphal stage) or when infestation is predicted to occur. Thus, early introduction of Nosema increases the probability that higher mortality will occur during critical periods such as molting. These factors are supported by tests described in Henry and Onsager (1982) and Henry (1971).

4-2 The reference for these statements is Henry et al. (1973). The reference has been added to the text. APHIS agrees that Nosema applications have not been successful in reducing grasshopper populations in every case. To date, Nosema has not been tested at optimum infestation levels or stages of development. Variation from this optimum "window" results in ambiguous treatment results. The plans for the IPM pilot project include introducing Nosema during optimum treatment windows and quantifying current season and long-term results.

4-3 The natural infection levels reported by Henry and Onsager (1982) for test plots in Montana have been added to the discussion. The 5-percent level reported by Henry (1972) for tests in Idaho represents an average of levels ranging from 1.6 percent to 8.11 percent over 5 years. Thus, it is reasonable to conclude that natural levels of infection vary according to susceptibility of the species present, grasshopper density at a given site, developmental stages, and other site-specific factors.

4-4 The reference for the transmission rate in the laboratory has been added to the text. Note that the text identifies that the transmission rate is reported from laboratory studies.

4-5 The statement that Nosema is most effectively transmitted at densities of 15 to 22 grasshoppers per square yard is not meant to be a prescription for the time to introduce Nosema. Because Nosema is slow acting, it is most effective if introduced early in an infestation so that as densities increase, its pathogenic effects can take action during critical periods such as molting and when spores are being produced for the succeeding season (Henry, 1972). Introducing Nosema when populations have already reached high densities will not provide an opportunity for Nosema's full potential to be realized. As predictive modeling capabilities are refined, it is anticipated that Nosema can be tested and used in a more preventive approach during

optimum treatment windows. This will be one emphasis of the IPM pilot project.

4-6 The reference for this statement (Henry et al., 1973) has been added to the text. According to Hewitt and Onsager (1983), the potential lifespan of grasshoppers may be 14 to 16 weeks after hatching; however, they note that the actual lifespan in nature is subject to moderating factors. In a field experiment near Sheridan, Wyoming, longevity varied from 95 days at low densities to 30 days at high densities. These data indicate that infected grasshoppers do in fact have a shorter lifespan.

4-7 The 1985 Wright memo on the status of Nosema is maintained in the administrative record for this EIS and is available to the public on request. In addition, it was printed as an appendix in the 1986 Supplement to the APHIS Rangeland Grasshopper Cooperative Management Final EIS.

4-8 The application rate used by Ewen and Mukerji was incorrectly converted in the draft EIS and has been corrected in response to your comment. In addition, the results of the Henry (1971) study have been added to the text.

4-9 The statement to which you refer means that all infected individuals collected had trace levels, not that all collected individuals were infected. Of the individuals collected, 8 to 17 percent of the nymphs were infected. At higher than trace levels of infection, the nymphs would not have survived, and transmission of the Nosema would not have been achieved.

During the year after treatment in the Billings experiment described by Henry and Onsager (1982), grasshopper densities were reduced to 0.2 to 1.6 grasshoppers per square meter. Thus, Nosema succeeded in reducing populations the following year to the point that densities were too low to continue transmission of the infection. Also, see response 4-2.

4-10 The transmission of Nosema by cannibalism is described in Henry (1972). Henry stated that "the principal means of transmission of *N. locustae* in nature appears to be through cannibalism."

4-11 Comparable results could be achieved with Nosema and chemicals if both are applied at their optimum point of efficacy. That is, if Nosema is applied by the third instar, it would spread to later hatches and provide

continued control; and if malathion is applied before oviposition occurs, it would prevent hatching later in that season or the following season. The relative efficacy of Nosema versus chemicals will vary as application times deviate from these optimum windows. (Onsager, personal communication, 1987.)

4-12 APHIS agrees that malathion is more efficacious than Nosema or carbaryl bait after the fourth instar. However, in cases where late season treatment is needed but species or resources sensitive to malathion and acephate are present, it may be impossible to treat. The text has been revised to reflect this more clearly.

4-13 See response 3-1.

4-14 The 500-foot programmatic buffer zone is expected to adequately protect the specified water bodies from drift when implemented in conjunction with other drift control procedures, such as not spraying when winds exceed 10 miles per hour, normally when temperatures exceed 80 °F, and the like. (See operational procedure #1 for ULV aerial application.) If conditions at a specific treatment site require a larger buffer zone, the necessary protection measures can be developed in the site-specific environmental analysis.

4-15 See response 2-1.

4-16 Thank you for your comments.

Letter 5

5-1 APHIS believes that it has complied fully with NEPA regulations in developing and analyzing the programmatic alternatives. APHIS agrees that IPM involves a systems approach to grasshopper management. The systems approach is embodied in the surveying, controlling, monitoring, and methods development components of APHIS' program as described in chapter 1 in the section entitled "APHIS' Cooperative Grasshopper Management Program." The descriptions in chapter 2 differentiate among alternatives by emphasizing the different control methods used under each. Thus, the mix of control methods described under the IPM alternative, along with the components of the APHIS program (described in chapter 1), provide the systems approach to IPM.

Further, chapter 2 describes how the IPM pilot project will test various control methods for future use, refine APHIS' predictive modeling and data base capabilities using surveying and monitoring results, develop economic thresholds that fit particular rangeland situations,

prescribe treatments to minimize nontarget effects, and evaluate posttreatment environmental effects. In this way, APHIS has committed to continue to improve the systems approach to decisionmaking.

5-2 The surveying data routinely collected by APHIS during nymphal surveys will be used to improve APHIS' baseline data. Additional data to be collected in the IPM pilot project include weather data, information on grasshopper species, including their stage of development, numbers, and egg production; forage yield, species, and condition; animal grazing data and environmental sampling; and economic data. These data will be collected at 60 sites in the IPM demonstration area, in no treatment areas, and in two standard control programs outside the demonstration area. Pretreatment and posttreatment grasshopper counts will be conducted for each 1,000 acres treated in the demonstration area. These data will be used to improve APHIS' predictive modeling capabilities by identifying relationships between outbreaks, the conditions that trigger outbreaks, and various control methods. In this way, APHIS can encourage a preventive approach to grasshopper management.

5-3 The process of developing a site-specific control program will vary depending on the land owner/manager and other agencies involved, the presence of sensitive wildlife species, the level of infestation, and the like. The APHIS Grasshopper Program Manual and the standard operating procedures listed in table 2-1 in the EIS provide guidelines for APHIS and its cooperators in conducting control programs. Those guidelines, this EIS, and subsequent environmental assessments (EA's) are written to ensure that all components of the rangeland ecosystem are included in the decisionmaking process.

5-4 Table 2-1 presents detailed standard operating procedures to ensure that the appropriate environmental and health standards are met in any treatment involving APHIS funding. In addition, further site-specific mitigation measures may be developed as needed in EA's tiered to this EIS. APHIS only authorizes a control program if a request has been made and if compliance with standard operating procedures has been assured.

5-5 The referenced article for this figure, Parker (1939), has been provided to the Northwest Coalition for Alternatives to Pesticides (NCAP). Also see response 5-6.

5-6 As stated in numerous places in the text, APHIS does not use the figure of eight grasshoppers per square yard or any other figure as an arbitrary criterion for determining injury level. APHIS recognizes other site-specific factors, such as species composition, condition of the range, and cooperator concerns over the cost of the program, in assisting cooperators to determine whether an infestation has reached an economic threshold. One of the objectives of the IPM pilot project is to further develop economic thresholds that fit particular rangeland situations.

5-7 Although the figures given provide useful estimates of the magnitude of grasshopper damage, APHIS agrees that it cannot assume that all forage lost to grasshoppers was intended for other purposes. APHIS also agrees that, below certain levels, grasshoppers provide benefits to the ecosystem. After APHIS notifies land owners/managers that certain infestations will or have reached an economic threshold, it is ultimately the decision of the individual land owner/manager as to whether a specific infestation has economic implications that would cause him to initiate a request. Historical data have shown that this is often the case.

5-8 The requested source articles by Parker (1954) and Parker and Connin (1964) have been provided to NCAP. As stated in the text, the denuding of all vegetation in an area under a critical infestation negates any contribution to the litter layer described for lower levels of infestation.

5-9 The text has been revised in response to your comment.

5-10 One-third to one-half of the severed plant material grazed by grasshoppers falls to the ground as litter (Mitchell and Pfadt, 1974). Under heavy infestations, these quantities of litter reduce the photosynthetic area, inhibiting vegetative production and reducing root reserves. Thus, it is reasonable to conclude that the unconsumed forage is wasted under heavy infestations.

5-11 As noted in the section "Alternative 3--Integrated Pest Management" in chapter 2, "the primary aims of the IPM alternative would be to develop means by which outbreaks could be predicted and prevented and to develop alternative methods of grasshopper control (for both prevention and suppression) that reduce the use of chemical pesticides." One of the goals of the IPM project described in the EIS is to enhance APHIS' modeling capabilities for predicting injury levels

in order to be able to provide better guidance to its cooperators.

APHIS is committed to provide leadership in this effort. However, APHIS is legislatively authorized to conduct its control operations on request of the land owner/manager only. Thus, a preventive approach to outbreaks outside of the IPM pilot project requires not only APHIS' commitment but also a willingness on the part of private, State, and Federal cooperators to participate and invest in long-range surveying and control strategies rather than relying solely on a reactive approach.

5-12 This fact is documented in Parker (1954). APHIS program records do not show many requests for subsequent treatment from landowners/managers in the years immediately following treatment. Generally, requests for retreating areas do not occur before 7 years. Blickenstaff et al. (1974) documents seven cases when grasshopper control programs have not achieved control in following seasons and they address reasons for postseason failures. Among these reasons are cases where early maturing species have time to deposit substantial numbers of eggs before treatment; thus, populations may continue to increase the following year. Of the 1.2 million acres studied in Wyoming by Blickenstaff et al. during 1952 to 1958, approximately 3.8 percent required retreatment the following year.

5-13 The term "biological" in this case was meant to refer to the characteristics of infestations such as size, species composition, migration rate, stage of development, and so forth that help delineate a logical block where treatments can be effective. Thus, the 10,000-acre figure is both a logistical criterion and a biological or ecological one.

5-14 APHIS cannot plan for migration in conducting treatments because current technology does not allow for prediction of migration patterns.

5-15 Cropland itself is not treated under the APHIS crop protection program. However, rangeland acreage receiving crop border treatments and treatments of incipient infestations will vary from year-to-year, depending on infestation levels and requests received. In 1986, a total of 317,633 acres received crop border protection. Incipient infestations treated in 1986 included 2,512 acres in California, 6,128 acres in Nevada, and approximately 6,000 acres in Idaho.

5-16 Funding for the APHIS cooperative grasshopper control programs is determined by Congress. Under the preferred alternative, APHIS would use available funds in a long-range IPM approach to grasshopper control.

5-17 The elements you have listed, including the relationship between range management and grasshopper control; a preventive, long-range approach to control; and monitoring for the long-term consequences of treatments on the environment are all components of the IPM pilot project to be implemented under the preferred alternative. The text in chapter 2 has been updated to describe the research projected to occur in these areas in the first year of the IPM pilot project. APHIS agrees that there are times when a decision not to act is justified.

5-18 Under IPM, APHIS will continue to test nonchemical methods for future implementation. As stated in the text, Nosema has been tested extensively over the past decade and has been incorporated into the 1986 APHIS program. It will also be used in the IPM pilot project. However, limited production of Nosema, constraints on its use in terms of timing, and the current nonoperational status of other nonchemical methods require that APHIS continue to use chemicals in spray or bait form where other methods are not available or feasible. The EIS has thoroughly analyzed the risks of the chemicals, including ULV application, and APHIS has developed standard operating procedures to minimize these risks.

5-19 APHIS has thoroughly analyzed the risks to humans and nonhumans in the EIS. Exposures to the public or workers are not expected to exceed the acceptable daily intake (ADI) under routine conditions except in the unlikely situations of ingesting grains directly sprayed with acephate, ingesting quail directly sprayed with malathion or acephate when no degradation has occurred, or from a total of all exposures examined for malathion or acephate. (Please note that exposures to leafly vegetables are now considered under the accidental scenario, while exposure to grain is considered to be more likely in rangeland under the routine scenario.)

ADI's are established as the maximum dose that a person could safely take <u>every day throughout a lifetime</u> without harm to health. Also note that chronic exposures (on which ADI's are based) generally show effects at lower doses than acute exposures. Given the fact that the ingestion of a sprayed grain or quail prior to degradation would occur only once every 7 years (that

is, acute rather than chronic exposure) and given the extremely conservative (unlikely) assumptions surrounding the routine or accidental events examined, the conclusions made in the EIS are reasonable.

5-20 The text has been revised in response to your comments.

5-21 APHIS has not relied on NOEL's as standards for what is acceptable in terms of human safety. As explained in chapter 4 in the hazard analysis section, NOEL's derived from animal studies are reduced by a safety factor when estimating safe doses for humans to derive an ADI. The risk analysis in chapter 4 provides the safety factor used by EPA to set the ADI for each chemical. Tables have been added to chapter 4 of the final EIS to allow an easier comparison between estimated doses and ADI's, and margins of safety have been calculated as the ratio of estimated exposures to the lowest NOEL. APHIS has identified exposures in relation to both NOEL's and ADI's in the risk analysis and has described the implications of these exposures in terms of human health effects.

5-22 As stated in the section of the draft and final EIS entitled "Chemical Risk Assessment," EPA indicated that none of the pesticides currently proposed for use by APHIS contain inerts of toxicological concern. However, EPA has included petroleum hydrocarbons on its list of inerts of toxicological concern (U.S. EPA, 1986c). Because carbaryl is commercially formulated with petroleum oil and because diesel oil may be used as a carrier for carbaryl, APHIS incorporated a risk analysis of impacts on each resource element in the EIS.

Additionally, APHIS has conducted a risk analysis on aqueous formaldehyde, an inert ingredient of toxicological concern in Sevin XLR Plus, a formulation currently being tested for future use in the program. Chapter 4 of the final EIS has been revised to include the risk analysis of formaldehyde. A hazard analysis of formaldehyde has also been incorporated into appendix A, and its environmental fate properties have been incorporated into appendix B.

5-23 Under the preferred IPM alternative, APHIS proposes techniques that are efficacious and do not pose significant risk to the environment or human health. In addition, preventive techniques and long-range control will be emphasized in the IPM pilot project.

5-24 Since the publication of the draft, the routine environmental monitoring requirements, the monitoring to be

conducted during the IPM pilot project, and the monitoring and research programs for sensitive resources and migratory birds have been further developed in cooperation with the U.S. Fish and Wildlife Service. These programs are described in the final EIS in the monitoring section in chapter 1 and in the description of the IPM pilot project in chapter 2. Also, see appendix C.

5-25 Nosema underwent an extensive battery of testing for nontarget effects as a part of the EPA registration process. Nontarget tests included studies on acute inhalation toxicity (rats), field studies on wildlife hazards (avian species), subacute oral toxicity (rats), 13-week dietary administration (rats: F,L), bioassay of tissues of rats, intraperitoneal injections in mice, toxicity tests on mallard ducks and pheasants, acute LC_{50} (rainbow trout and bluegill sunfish), acute dermal toxicity (guinea pigs), primary skin irritation (rabbits), eye irritation (rabbits), tests on the viability of spores in ruminant animals, and a special report--"Large-Scale Test Control of Grasshoppers on Rangeland with Nosema Locustae" (Henry and Onsager, 1982). These studies were made available by ARS and EPA to potential registrants to be used toward registration. Because none of these studies revealed adverse nontarget effects, monitoring for Nosema in nontarget species as a result of APHIS' control program is not considered necessary.

5-26 Public participation has been integral to the development of programmatic alternatives and analyses in this EIS. Land owners and Federal and State land managing and wildlife agencies are involved in planning and developing site-specific treatments and assessments. In addition, public meetings are held in advance of proposed programs to obtain input from interested parties. (See Operational Procedure No. 3 under "All Methods" in table 2-1.) If, in preparing an environmental assessment for a specific treatment APHIS determines the potential for significant unmitigated impacts, an EIS including public participation would be conducted.

5-27 Thank you for your review and comments. They will be considered in preparing the final EIS.

Letter 6

6-1 See individual responses to these points as they are made in more detail in the main body of the comment letter.

6-2 Since the publication of the draft, the IPM pilot project has developed a tentative budget, staffing, and work plan for the first year of operation. This information has been included in chapter 2 of the final EIS.

APHIS has incorporated Nosema into its 1986 program and is committed to its use in following years. The pilot project will use Nosema on up to 40,000 acres provided that optimum conditions for its use occur. Because the use of Nosema in a preventive approach outside the pilot project depends also on the willingness of land owners or managers to cooperate and because, to date, production of Nosema has been limited, APHIS cannot preestablish programwide target acreages for Nosema treatment in upcoming years.

Once a method is determined efficacious and safe in the IPM pilot project, the IPM Work Group will recommend to APHIS that that method be incorporated into the cooperative control program. Registration of the method may be sought by the manufacturer during this process. The IPM Work Group has developed an information component to ensure that farmers, ranchers, environmental groups, public agencies, and other interested parties are informed of the progress of the IPM pilot project and new methods testing. This effort will include maintaining an active mailing list for factsheets and press releases to all media.

6-3 Cultural/mechanical methods are dismissed as a single programwide means of control. However, range management is included for potential future use in the preferred IPM alternative, and the text has been revised in the final EIS to describe plans for research in range management under the first year of the IPM pilot project. This EIS analyzes the environmental effects of those methods currently operational. As range management or other means of control become available for implementation in APHIS' control program, the impacts will be analyzed in a supplement to this EIS. Also, see response 5-2 regarding APHIS' preventive approach efforts.

6-4 Nosema is included and compared to the other currently available control methods in chapter 2, and its impacts are analyzed along with those of the chemicals in chapter 4.

6-5 The mixed carbaryl/Nosema bait or alternating swaths of carbaryl and Nosema baits are not dismissed. Rather, they are included as potential future components of APHIS' program under the IPM alternative. Registration

requirements would be explored by the manufacturer if future testing demonstrates that the carbaryl/Nosema bait mixture should be recommended to be incorporated into the cooperative control program.

6-6 The impacts of livestock grazing are beyond the scope of the EIS or APHIS' purview. The impacts of grazing are addressed by Federal land management agencies in documents such as BLM and Forest Service grazing management plans.

However, APHIS does recognize the interrelationship between grasshopper infestations and rangeland condition, and range management as a means of grasshopper control is being researched in the IPM pilot project. The role of grasshoppers in the rangeland ecosystem is addressed in chapter 1, and the continuing research on the interrelationship between grasshopper damage and rangeland conditions is discussed under the descriptions of research and the IPM pilot project in chapter 2.

6-7 Rangeland in poor condition can be managed for recovery. Grasshopper control can be used to assist in restoring poor rangeland to satisfactory or better condition.

6-8 You are correct in describing this as a programmatic EIS that analyzes the full range of chemical and biological methods currently available in APHIS' control program. General considerations regarding the selection of a control method for a specific site are provided in the section entitled "Selection of a Control Method--Factors to be Considered." However, the choice of a control method for a specific treatment depends on site-specific conditions. Consideration of site-specific conditions is the purpose of the site-specific EA. APHIS has recently prepared guidance for Federal and State field personnel involved in preparing site-specific EA's. This guidance requires the consideration of site-specific alternatives. With regard to public participation at the site-specific level, see responses 5-26 and 6-9.

Because the choice of a method and timing of treatments depend also on the requesting land owner/manager, APHIS cannot preestablish target acreages for each method. However, APHIS is committed to making available Nosema and other nonchemical methods (as they become operational) and to advising landowners on their use.

6-9 See response 5-26. The adult infestation map made in the fall is available upon request from the national,

regional, or State APHIS PPQ offices. (There is no mailing list for that map.) It should be noted that this map cannot be used to accurately predict subsequent nymphal populations that may actually require treatment in the spring or summer.

The public comment period you have referred to applies to environmental impact statements only (40 CFR 1506.10). The case to which you have referred made its finding on public comment requirements based on the fact that the EIS did not provide a full discussion of alternatives. This EIS provides a full discussion of programmatic alternatives. Additional considerations not covered in this EIS will be addressed in site-specific EA's. If the site-specific EA reveals potentially significant unmitigated impacts, an EIS involving public participation will be undertaken.

6-10 As you point out in your comment, the usual method is to convert an experimental LD_{50} to an LC_{50} in the environment and to compare that converted LC_{50} directly with an EEC. That conversion requires a knowledge of the diet of the animal in question. The method used in the EIS is simply the reverse of that procedure but it considers all routes of exposure, not just dietary, for the comparison. It is therefore more conservative than the EPA method because the contribution to a total dose from all media is considered.

With regard to site-specific wildlife impact analysis, see response 6-13.

6-11 In response to your comment, the summary statements on wildlife have been revised.

6-12 The typographical error has been corrected.

6-13 As noted in chapter 5 of the EIS, APHIS has prepared a guidance document to be used by APHIS field personnel and personnel from cooperating Federal and State agencies involved in preparing site-specific EA's. This guidance document sets a framework for the environmental and human health issues that must be considered on a site-specific basis. It calls for site-specific consideration of Federal, candidate, and State-listed endangered and threatened species; species at risk; limited range or unstable populations; and species not represented by the analyses in the programmatic EIS. Field-level consultation with Federal, State, and local wildlife agencies will assist in identifying the presence of these species and in developing necessary mitigation measures.

6-14 First, it should be noted that the 1-mile buffer around peregrine falcon and bald eagle nests is a no-treatment zone, while an additional 10-mile no-aerial spray zone is proposed for peregrine falcons (consistent with the 1986 Fish and Wildlife Service Biological Opinion). Table 2-1 contains minimum standard operational procedures to protect endangered and threatened species that would be required for all treatments. As noted in the EIS, additional requirements or buffer zones for federally endangered and threatened species are being developed in consultation with the Fish and Wildlife Service at this time and will be presented in the Biological Opinion. APHIS is committed to follow all requirements reached in consultation with the Fish and Wildlife Service. The Denver Regional Office of the Fish and Wildlife Service has been designated as the official contact for consultation on the grasshopper management program.

6-15 Your comments have been noted.

Letter 7

7-1 See response 5-11.

7-2 See responses 5-26 and 6-9.

7-3 Under the preferred IPM alternative, long-range planning and use of Nosema would be included in the APHIS program.

7-4 See response 6-7.

7-5 The implementation of cooperative control activities is outlined in chapter 1 in the section on control treatments. The APHIS Grasshopper Program Manual and Aerial Application Manual specify in more detail the responsibilities of Federal, State, or local treatment site personnel or contractors.

As the agency best equipped to manage grasshopper control, APHIS has entered into Memoranda of Understanding with the Forest Service and the Department of the Interior to administer control activities on Federal lands. In addition, APHIS has entered into cooperative agreements with the affected States. However, APHIS conducts control operations only at the request of the Federal or State land managing agency or landowner. The requesting agency may be asked to provide assistance in flagging, storage, and arranging for equipment and services. Actual treatments are conducted by private contractors under APHIS or State supervision.

Letter 8

8-1 See response 6-6.

8-2 The impacts of representative migrating and nonmigrating wildlife species are analyzed in chapter 4 of the EIS. Site-specific species at risk and potential impacts of specific treatments will be identified in site-specific environmental assessments, which will involve field-level conferences with Federal and State wildlife officials.

8-3 Your comment has been noted.

Letter 9

9-1 Thank you for your comment.

9-2 See response 6-6.

9-3 Your comment has been noted.

Letter 10

10-1 The text in the summary and chapter 1 has been revised to clarify State and Federal responsibilities for preparing site-specific assessments.

10-2 Many of the operational procedures provide guidance on how treatments should be conducted in order to meet label requirements. In addition, APHIS has provided additional requirements that are tailored to its operating practices and that ensure adequate protection of the environment and human health. APHIS and the cooperating agencies have established the 500-foot buffer zone for aerial chemical sprays and the 200-foot buffer zone for carbaryl bait to ensure that drift does not reach the specified water bodies, and thus compliance with the label requirements and protection of the environment is achieved.

10-3 See response 10-2. Recreational facilities would include places, such as campgrounds, where people may be outdoors and exposed to pesticides.

10-4 See response 2-1.

10-5 See response 10-2.

Letter 11

11-1 Your comments have been noted. See response 5-11.

11-2 Because the commenter has not named the references to which she is referring, APHIS cannot respond to concerns regarding chromosomal damage to plants in some cases. The findings on malathion's effects on plants are based on the best information available to APHIS. As stated in the text, although malathion may be slightly phytotoxic to some ornamental or fruit-bearing species, it is not likely to injure rangeland vegetation in APHIS control programs. Data gaps regarding the chemicals

have been identified, and the risk analyses on the chemicals and petroleum oils have been conducted accordingly.

11-3 We are not aware of convincing evidence of delayed neurotoxicity as a result of low-level doses comparable to those expected for humans exposed to any of the three proposed insecticides for grasshopper control. The study by Duffy and Burchfiel involves the long-term effects of sarin, a nerve gas produced as a military weapon. The U.S. Army study cited in the comment showed some behavioral changes in rats injected with 50 mg/kg of malathion and significant decreases in cholinesterase levels at 100 and 150 mg/kg. Neither behavioral nor physiological changes were noted in the study at 25 mg/kg. These doses are much higher than those expected as a result of malathion treatments for grasshopper control. For example, the highest expected doses to members of the public under routine or accidental conditions were 0.2 mg/kg for eating leafy vegetables that had been directly sprayed. Routine doses to workers are also expected to be much lower than the doses used in the Army study. Accidental exposure to workers from a spill of concentrated malathion could be great enough to cause toxic effects, as discussed in chapter 4.

The wildlife risk analysis indicates doses higher than 50 mg/kg for some species. The behavioral effects of these doses have been addressed in the wildlife risk analysis in chapter 4.

11-4 It is true that the procedure for cancer risk estimation is subject to uncertainty. Major sources of uncertainty are (1) the inaccuracies of exposure estimation and (2) uncertainty regarding the form of the dose/response relationship. While the uncertainties cannot be avoided, the approach taken in the EIS has attempted to avoid underestimation of risk. Exposures have been calculated assuming conditions conducive to exposure, repeated exposures, and multiple routes of exposure. Cancer risks were estimated using a linear model for low-dose extrapolation. Although none of the various models available for low-dose extrapolation has gained universal acceptance in the scientific community (U.S. OSTP, 1985), the linear model predicts higher cancer risks than several possible alternatives.

The use of animal data for prediction of cancer in humans is necessary because adequate human data are not available. Interspecies extrapolation involves some uncertainty that cannot be eliminated at this

time, but it relies on the commonly accepted belief that "on a biochemical and molecular level, there are important similarities among mammalian species" (U.S. OSTP, 1985).

Letter 12

12-1 See response 3-1.

12-2 See response 2-1. The prespray reconnaissance flight is a standard operating procedure that serves several purposes, including a final check that bees have been removed, checking program area boundaries, buffer zones, and the like.

12-3 Observations in the laboratory indicate that dry material is needed in the diet of grasshoppers in their early instar stages. Thus, bran baits would be most readily accepted by the earlier instars in an infestation that is being treated (third or fourth instars). (Onsager, personal communication, 1987).

12-4 The misspelling has been corrected in response to your comment.

12-5 The text has been revised in response to your comment.

12-6 In response to your comments, the findings of Scharff (1960) have been added to text.

12-7 Because you have not provided a reference for your statement, APHIS cannot respond. However, it is generally accepted that, below certain levels of infestation, grasshopper feeding provides benefits to the ecosystem.

12-8 The text you refer to accurately reflects the timing of the adult survey conducted by APHIS.

12-9 This sentence accurately reflects the objectives of the delimiting survey intended by APHIS.

12-10 The text has been revised in response to your comment.

12-11 Although there are currently no federally endangered or threatened orthopterans, the Idaho point-headed grasshopper (Acrolophitus pulchellus) is being considered as a Federal candidate species. The grasshopper is found only in the upper Birch Creek Valley in east-central Idaho, which is not presently a planned treatment area. The text has been revised in response to your comment.

12-12 Although the table you refer to has been removed, the text in chapter 2 has been clarified to explain that

the application rate for Nosema is 6 million to 1 billion spores per acre, or 1 pound of bait per acre. The application rate for Mormon crickets is recommended to be 2 pounds of bait per acre, or 12 million to 2 billion spores per acre.

12-13 The Wyoming Basin has been described in the text in accordance with Bailey (1980) as plains and tablelands that occur among the eastern Rocky Mountains at elevations of 6,000 to 8,000 feet in central Wyoming. Although Bailey (1980) characterizes the Wyoming Basin as an ecoregion separate from short-grass prairie, APHIS has consolidated the two similar regions for the programmatic level of analysis.

12-14 In response to your comment, additional common grasses of the mixed-grass prairie have been added to the vegetation discussion under the short-grass prairie analysis region section. (The mixed-grass prairie is consolidated into the short-grass prairie region for this programmatic analysis.)

12-15 The text has been revised in response to your comment.

12-16 The text has been revised in response to your comment.

12-17 The text has been revised in response to your comment.

12-18 The numbers given are the AUM equivalent of forage destruction caused by 8, 16, and 32 grasshoppers per square yard. The table has been clarified in response to your comment.

12-19 The figure has been removed from the text.

12-20 The cost analysis is based on the Mann et al. (1983) reference, which is maintained in the administrative record and available to the public on request.

12-21 The text has been rearranged for clarification.

Letter 13

13-1 Although this information has been noted, APHIS is awaiting verification and publication of the data before citing it.

13-2 Note that chemicals also provide residual control in subsequent years. Mann et al. (1983) prorated the residual benefits of both chemicals and Nosema in his economic analysis, the results of which are presented in table 4-31. These results show that Nosema currently has a higher per-acre cost than chemicals. APHIS agrees that, as more Nosema is used, production

costs for Nosema will decrease and that Nosema has notable environmental advantages.

13-3 Nosema will be used when conditions that are optimum for its use are present and when it has been requested, regardless of the size of the area to be treated. This may include using Nosema to treat incipient infestations or large acreages.

13-4 Use of Nosema alone in the entire APHIS program is not feasible for the reasons given in chapter 2 of the EIS. Even if production of Nosema were to increase enough for its use on the entire treatment acreage, APHIS would continue to need to be able to use chemicals to respond to requests to control outbreaks that have already reached critical levels. As noted by the commenter, Nosema is included as an available means of control under the preferred IPM alternative.

13-5 See response 6-5.

13-6 See response 13-2.

13-7 See response 4-11.

13-8 The operational procedures in listed table 2-1 have been revised to clarify that the 500-foot buffer zone around nonregistered crops is for chemical aerial broadcast methods only. Thus, the use of Nosema may be appropriate within the buffer zone.

13-9 This point has been added to the text. See response 13-2.

13-10 This fact is mentioned in the section on wildlife impacts in chapter 4. In response to your comment, it has also been added to the sections entitled "Impacts on Producers of Honey Bees and Impacts on Alfalfa Cultivators" in chapter 4.

13-11 The text has been clarified in response to your comment.

13-12 The buffer zones are listed under the control methods to which they apply in table 2-1, Operational Procedures. Note that Nosema is prohibited in the 1-mile no-treatment zone around peregrine falcon or bald eagle nesting sites to preclude any human disturbance of those sites. However, Nosema may be useful in other sensitive areas where chemical baits or ULV sprays may be restricted or prohibited.

13-13 See response 13-3.

Letter 14

14-1 APHIS has established a 1-mile no-treatment buffer zone around peregrine falcon and bald eagle nesting sites in cooperation with the U.S. Fish and Wildlife Service to ensure adequate protection of these endangered species from human disturbance and possible direct or indirect effects of pesticides.

14-2 It is the responsibility of the APHIS contracting officer's representative to ensure that aircraft, dispersal equipment, and pilots meet the necessary requirements outlined in APHIS aerial contracts.

14-3 Normally, notification is achieved through public notices published in local newspapers or broadcast over local radio stations. In some cases, personal notification will be used, such as when sensitive individuals are known to live in the treatment area.

14-4 See response 14-1.

14-5 See responses 3-1 and 10-2. Nosema would be available for use in these buffer zones where chemicals are not allowed near water.

14-6 The 10-mile-per-hour maximum is consistent with the pesticide label requirements.

14-7 This operational procedure has been designed to ensure maximum efficacy of the treatment by preventing washoff of the pesticide from the plant surface. "Wet" would therefore pertain to any amount of moisture, including dew, that would hinder the adherence of the pesticide to the vegetation.

14-8 See responses 3-1 and 10-2.

14-9 Treatment personnel are expected to use common sense in determining whether site-specific conditions, such as depth of water table, soil, or topographic characteristics, or weather would make a proposed treatment area vulnerable to leaching or runoff if chemical sprays or baits are used. Note that in most rangeland areas, the water table is not high, particularly during the summer when treatment occurs.

14-10 See response 12-2.

14-11 See response 2-1.

14-12 The need for and practicality of implementing this recommended mitigation measure is a decision reached

between local program officials and local law enforcement officials.

14-13 The second notification is recommended rather than required. It has been revised to eliminate the 14-day period and to provide alternate notification channels. Given the required early first notification and the other bee protection measures listed, bees should be adequately protected.

Letter 15

15-1 Thank you for this information.

15-2 Your comment has been noted.

15-3 Henry (1969) reports that the host range of Nosema includes 58 species of Orthoptera. All of the species you have listed are affected.

15-4 Under IPM, APHIS would continue to enhance its data base and prediction capabilities so that Nosema could be used effectively before populations reach high densities. The IPM pilot project includes using Nosema at optimum (early) treatment times (rather than in crises) to demonstrate its potential for current season and long-term control. However, IPM also includes the continued use of chemicals where immediate control is needed for critically high densities.

15-5 As noted in chapter 2 of the EIS, the IPM pilot project includes further research on E. grylli and entomopox viruses.

15-6 Your comment has been noted.

15-7 See response 3-1.

15-8 See response 14-9.

15-9 See responses 3-1 and 14-9.

15-10 The APHIS officer in charge is responsible for notification of registered beekeepers to inform them of the need to move or otherwise protect commercial bees in areas where treatments are planned. Once the required notification procedures have been met, it is the landowner's responsibility to ensure that the bees are moved or protected. APHIS will not proceed with operations until bees are moved or protected. APHIS is responsible for bee kills that can be proven to be a result of a cooperative control program.

15-11 See response 2-1.

15-12 Thank you for your comments.

Letter 16

The operational procedures in table 2-1 have been developed based on pesticide label requirements, APHIS program manuals, and other guidance developed with the cooperating agencies. These procedures have been developed to provide acceptable protection to human health and the environment, while still allowing efficacious and cost-effective control of grasshoppers. Please note that, in response to public comment, APHIS has clarified the procedures regarding spraying in the vicinity of bees and buffer zones around certain bodies of water (see responses 2-1 and 3-1). Given these clarifications, APHIS believes that its cooperators and contractors will not be prevented from implementing effective control programs.

Letter 17

17-1 Thank you for your comments. Preseason coordination is a routine procedure in APHIS' cooperative efforts with BLM.

17-2 See response 5-11. APHIS agrees that Nosema would be particularly useful on sensitive environments and Federal wildlands.

17-3 The correction has been made in the text.

Letter 18

18-1 Thank you for your review and comments.

18-2 Your comments have been noted.

18-3 See responses 10-2 and 16.

18-4 See responses 14-9 and 16.

18-5 See response 2-1.

18-6 The 1986 Biological Opinion issued by the Fish and Wildlife Service stated that the buffer zones would apply to hack sites to be used during the current year. The application of these buffer zones to new hack sites or future nest sites is currently being considered in consultation with the Fish and Wildlife Service and will be resolved prior to any treatment in 1987.

18-7 APHIS has attempted to use these conservative assumptions to ensure that the upper limit of risk is analyzed in accordance with NEPA implementing regulations. As you have pointed out, actual operations are less likely to involve such risks.

18-8 See response 18-7. In response to your comment, the baseline cancer risk has been described in chapter 4 in the human health risk analysis and compared to the added risk of getting cancer from exposure to the insecticides.

18-9 Since the publication of the draft, the IPM pilot project has developed a tentative budget, staffing, and work plans for the first year. This information has been included in chapter 2 of the final EIS. Post-treatment evaluation and environmental monitoring for the efficacy of treatments and their effects on the environment are included in the project. Included is monitoring for effects on aquatic species in the demonstration sites.

18-10 See response 14-5.

18-11 See response 18-7.

18-12 You are correct that tiering or supplements would apply to the final rather than the draft EIS. This will be implicitly understood in the final EIS.

18-13 Although common names have not been added to the summary for the sake of brevity, the common names have been added to figure 3-7 in chapter 3. Note that some species do not have common names.

18-14 The text has been revised in response to your comment.

18-15 The text has been revised in response to your comment.

18-16 The text has been revised in response to your comment.

18-17 The correction has been made.

18-18 The correct elevation is 280 feet below sea level. The text has been changed accordingly.

18-19 The text should read "bighorn sheep" and has been changed accordingly.

18-20 EPA includes crops other than "sown" agricultural crops (such as rangeland) on its labels. Thus, it cannot be assumed that pinon trees whose nuts are harvested are excluded from label restrictions.

18-21 See response 3-1.

18-22 The text has been changed to include the coyote as a fur-bearing species.

18-23 The text has been changed to include the location of Navajo Lake in northern New Mexico.

Letter 19

19-1 See response 5-11.

19-2 APHIS is authorized to conduct treatments upon request from the land manager/owner only. A determination of cost versus benefit, including intrinsic value of the rangeland, is thus made by the land owner/manager threatened with an infestation. As stated in the cost analysis in chapter 4, "in some areas it may not be economical to treat for grasshopper infestation because of the low forage production and low stocking rates." Also see response 5-6.

19-3 APHIS has examined the nontarget and food chain effects, as well as cumulative and synergistic impacts, in chapter 4 of the EIS. Monetary values cannot logically be assigned to these effects. The CEQ regulations state that "for purposes of complying with the act, the weighing of the merits and drawbacks of the various alternatives need not be displayed in a monetary cost-benefit analysis and should not be when there are important qualitative considerations" (40 CFR 1502.23).

19-4 The consideration of environmental as well as monetary costs is emphasized under IPM. See, for example, the section entitled "Selection of a Control Method--Factors to be Considered" in chapter 2 of the EIS.

19-5 See response 6-6.

19-6 See response 5-11.

19-7 Your comments have been noted. Site-specific environmental assessments will consider these issues as they relate to the proposed treatment area.

19-8 The discussion of wildlife impacts from multiple applications in chapter 4 refers to the discussion of effects under single applications and states that toxic effects would not likely be <u>greater</u> than under single treatments because the chemicals degrade rapidly. Direct toxic effects may occur under multiple treatments just as under single treatments. The continued loss of an insect food supply under multiple treatment is an impact over and above that.

19-9 Note that the cumulative effects section in chapter 4 examines (1) the programmatic effects of APHIS grasshopper control activities alone <u>and</u> (2) the

incremental impacts over time of APHIS-funded actions in conjunction with those of other agencies or groups. This analysis considers background concentrations of the insecticides and their environmental fate and persistence.

19-10 Protection measures for federally listed species are being developed at the programmatic level through formal consultation with the U.S. Fish and Wildlife Service in the Biological Assessment/Biological Opinion process. When specific areas needing treatment have been tentatively identified, the Fish and Wildlife Service will assist APHIS with site-specific biological and distributional information for endangered and threatened species. Candidate species and limited range or unstable populations will be considered in the site-specific environmental assessment. APHIS will also work with State wildlife officials to identify any State-listed species within the proposed treatment area. Impacts on these species and needed protection measures will be addressed in site-specific environmental assessments.

19-11 The routine monitoring requirements for all cooperative control programs have been increased. See the revised text in chapter 1 and appendix C. The monitoring program will be conducted each year. Monitoring results will be used to evaluate the impacts of control activities and to refine operational procedures as needed. Additionally, under the IPM pilot project, an environmental monitoring plan has been designed to further develop APHIS' data base. See the revised text in chapter 2 on the IPM pilot project and appendix C. Finally, the sensitive area monitoring procedures to be performed in sensitive areas have been further developed as indicated in chapter 1 and appendix C.

19-12 The summary of your comments has been noted.

Letter 20

20-1 Thank you for your comments.

20-2 See response 6-8.

20-3 See responses 5-2 and 5-17.

20-4 See response 5-2.

20-5 See response 6-8.

20-6 Your comment has been noted.

20-7 See response 19-2.

20-8 See response 6-13.

20-9 The guidance for preparing EA's includes the development of site-specific alternatives. With regard to cost/benefit analysis, see responses 19-2 and 5-7.

20-10 See response 5-6.

20-11 See responses 6-13, 5-26, and 6-9.

20-12 This information is maintained in field office files. CEQ guidance for implementing NEPA states that "since the EA is a concise document, it should not contain long descriptions or detailed data which the agency may have gathered" (46 FR 18037).

20-13 See responses 5-26 and 6-9.

20-14 APHIS guidelines are written to minimize pilot and equipment error. Relative to other pesticide programs, grasshopper programs are conducted in generally unobstructed terrain. APHIS records show that there were four accidents involving pesticides in 1986; one in 1985; and none in 1984 and 1983. When a spill occurs, a decision is reached among State officials, the APHIS officer in charge, and the National Residue Monitoring Laboratory in Gulfport, Mississippi, concerning whether the spill will be monitored by APHIS or the State. Accident sites cleaned and monitored by APHIS are done so in compliance with PPQ guidelines for managing and monitoring pesticide spills. Records of the monitoring data conducted at spill sites are maintained at the National Residue Monitoring Laboratory or by individual States. Normally, if a spill does not involve Federal land, the State monitors the spill.

20-15 The risk analyses in the EIS have been based on conservative assumptions and tend to overestimate risks, including the amount of chemicals likely to reach aquatic systems. Buffer zones and other operational procedures designed to protect aquatic systems will be adhered to in all APHIS operations. The site-specific EA provides yet another level of analysis and an opportunity to develop other site-specific mitigation measures.

20-16 The risk analysis for wildlife has been based on EPA-accepted procedures for ecological risk assessment. Reptiles and amphibians are represented in the analysis. Consideration of limited range or unstable populations or other wildlife not represented in the programmatic EIS will take place in site-specific EA's.

20-17 See response 5-24.

20-18 See response 6-8.

20-19 See responses 6-8 and 6-13.

20-20 See response 6-5.

20-21 The concerns regarding the eight grasshoppers per square yard figure are addressed in chapter 1 in the section entitled "Control Methods" and in chapter 2 in the section entitled "Selection of Chemicals and Timing of Application." In addition, see response 5-6.

20-22 The relationship between grazing management and grasshopper outbreaks is discussed under the section entitled "Potential Future Components of the IPM Alternative" in chapter 2. The text in that section has been revised in the final EIS to include the first year plans for research in this area under the IPM pilot project.

20-23 The wildlife and aquatic risk analyses address the effects of a cholinesterase suppression using the best information available. The text of chapter 2, "Potential Future Components of the IPM Alternative," has been revised to describe the research to be conducted on the effects and degree of cholinesterase inhibition on migratory birds.

20-24 Prediction of outbreaks remains difficult, and it was particularly difficult in 1985 when an unexpectedly large outbreak occurred on Federal land in Idaho and Utah. See response 5-2 regarding efforts to improve APHIS' predictive modeling capabilities.

20-25 Your comments have been noted.

Letter 21

21-1 APHIS has addressed this proposal in correspondence with Governor Janklow. APHIS is a primary cooperator in the South Dakota project and will continue in its involvement to develop data that are applicable to the IPM pilot project. The IPM pilot project complements and expands on the work being done by South Dakota. Also, see response 6-2.

21-2 See response 3-1.

21-3 For the purpose of the operational procedures, perennial streams are defined as streams that flow continuously throughout the year. Both perennial streams and streams reduced to seasonal pools are protected by the buffer

zones because they are likely to support higher aquatic life. See response 3-1.

21-4 It is part of APHIS' program planning process to survey for the presence of leafcutter and alkali bees in control areas. Although alfalfa seed production may not be a factor during grasshopper control in South Dakota, it may be in other States.

21-5 See response 2-1.

21-6 See response 14-13.

21-7 APHIS feels that the eight analysis regions are sufficient for the programmatic level of analysis. In response to public comment, APHIS has included a description of the mixed-grass prairie under the vegetation section of the section entitled "Short-Grass Prairie Analysis Region." Further, it should be noted that some of the objectives of the IPM pilot project are to develop economic thresholds that fit particular rangeland situations and to monitor range conditions to strengthen APHIS' data base and control strategies.

21-8 Dry-land alfalfa is not included in the definition of rangeland because it is planted with the intent to harvest. Crops planted and then grazed because of insufficient growth or drought will be considered cropland for the purposes of grasshopper control operations. This position has been reflected in the current definitions of rangeland and cropland that have been incorporated in the glossary of the final EIS and that will be incorporated in the APHIS Program Manual.

Letter 22

22-1 See response 16.

22-2 Under the IPM alternative, APHIS will use available chemical and nonchemical methods and will continue to test new methods under the IPM pilot project and in its methods development program. In testing and using these methods, APHIS must comply with all applicable Federal and State regulations designed to protect human health and the environment. These include label restrictions and testing protocol.

Letter 23

23-1 If we understand what you mean by interpretative program, such a program is not feasible for incorporation into cooperative control operations. APHIS' Legislative and Public Affairs staff will continue to provide press releases and respond to information on control programs upon request from the public.

23-2 These alternatives were eliminated from detailed study.

23-3 Your comments have been noted.

23-4 Helicopters are not used in grasshopper control programs because of their higher cost and because the areas treated are typically too large for the use of helicopters.

23-5 See response 16.

23-6 See response 10-2.

23-7 In response to your comment, the operational procedure has been revised to refer to lactating dairy animals.

23-8 Labels for all three chemicals warn that they are toxic to honey bees. Thus, this restriction, as taken from the Sevin 4-Oil label, is designed to protect domestic bees from the toxic effects of all three chemicals.

23-9 See responses 10-2 and 3-1.

23-10 See response 16. As stated in chapter 1 in the section entitled "Scope of the Environmental Impact Statement," "this EIS addresses APHIS-funded treatments on Federal, State, and private rangelands."

Letter 24

24-1 Your comments have been noted. Impacts on migratory birds have been represented at the programmatic level in the analyses of the American kestrel and lark bunting. A description of the migratory bird research to be conducted in the IPM pilot project has been added to chapter 2.

24-2 APHIS feels that the descriptions of the eight analysis regions and the use of representative species are adequate for the programmatic level of analysis. See response 6-13 regarding coverage of the site-specific environment in environmental assessments.

24-3 See response 24-2.

24-4 Findings of the Biological Assessments are incorporated by reference so that they do not have to be duplicated in the EIS. Since the publication of the draft, APHIS has prepared a new Biological Assessment for 1987 that contains proposed protection measures for endangered and threatened species for all affected States. The Fish and Wildlife Service will accept or modify these measures in its Biological Opinion. APHIS will comply with all measures developed in consultation with the

Fish and Wildlife Service. The APHIS Biological Assessment and the Fish and Wildlife Service Biological Opinion will be maintained in the administrative record and available for public review. See response 19-10.

24-5 See response 19-10.

24-6 Responses to your specific comments are given below.

24-7 See response 19-10.

24-8 In response to your comment, common fish species found throughout many of the analysis regions have been included in the overview in chapter 3 of the final EIS. Federally endangered and threatened fish species are now listed in the individual region discussions and in the overview.

The utilization of natural resources is discussed in general in the section "Land Uses" in the overview. However, economic values of specific resources will not be addressed in this programmatic EIS.

24-9 The text has been revised in response to your comment. State-listed species will be addressed in site-specific EA's.

24-10 The federally endangered and threatened species have been included in the text in response to your comment. State-listed species and candidate species for Federal listing will be addressed in site-specific EA's.

24-11 These major water bodies have been included in the text in response to your comments.

24-12 The text has been revised in response to your comments.

24-13 The text has been revised in response to your comments.

24-14 The sailfin molly has been deleted from the text in response to your comment.

24-15 These species have been added to the text in response to your comments.

24-16 See response 18-19.

24-17 These species have been added to the text in response to your comments.

24-18 Your comment has been incorporated into the text.

24-19 The text has been revised in response to your comment.

Letter 25

25-1 Thank you for your comments.

25-2 As you have noted, the incipient infestation provision allows for treatment of areas under 10,000 acres when needed.

25-3 See response 6-14. Except for the 1-mile no-treatment zone around peregrine falcon and bald eagle nesting sites, chemical and biological baits would still be available to protect landowners in the no-aerial treatment buffers.

25-4 Your comments have been noted.

25-5 These buffer zones have been developed in consultation with the U.S. Fish and Wildlife Service pursuant to Section 7 of the Endangered Species Act, which requires that endangered and threatened species and their critical habitat be protected from adverse effects, including those caused by human disturbance.

25-6 See responses 6-14 and 25-5.

25-7 See responses 25-5 and 25-3.

25-8 See responses 6-14 and 24-4.

25-9 See responses 16 and 3-1.

25-10 See responses 16 and 10-3.

25-11 See response 16.

25-12 The Fish and Wildlife Service is a cooperating agency and the Environmental Protection Agency is a reviewing agency for this EIS. Their concerns must be addressed in accordance with the Endangered Species Act, the National Environmental Policy Act, and their implementing regulations. See response 25-3.

Letter 26

26-1 Thank you for your comments.

26-2 See response 16. Also, please note that the operational procedures have been revised to indicate that the 500-foot buffer zone around nonregistered crops applies to aerially sprayed chemicals, while carbaryl baits are allowed up to 200 feet from oats, barley, and rye. In all other cases, carbaryl baits or Nosema would be allowed.

26-3 See responses 3-1 and 14-5.

26-4 See response 2-1.

26-5 See response 4-12.

26-6 The operational procedure has been revised to advise unprotected workers to stay out of treated areas until the insecticide has dried.

26-7 See response 1.

26-8 See responses 4-1 and 4-2.

26-9 The paragraph in the draft to which you refer lists factors that affect the cost-effectiveness of Nosema. As stated earlier in that section of the text, Nosema is currently the most expensive control method available. Also see response 13-2.

26-10 See response 13-2. As you have noted, APHIS will continue its efforts to enhance the effectiveness of Nosema under the IPM pilot project.

26-11 The impacts of grasshopper control on rangeland wildlife habitat and recreation resources have been analyzed in chapter 4 of the EIS, and operational procedures designed to protect these resources are presented in table 2-1. The benefits to wildlife and stream resources that result from protection from grasshopper infestations are addressed under the No Action alternative in each respective section in chapter 4.

26-12 Thank you for your comments.

Letter 27

27-1 Your comments have been noted.

27-2 Although your proposed rewording is consistent with APHIS' view of IPM, the text has not been revised because it reflects the definition adopted by the IPM Work Group in the documentation of its efforts.

27-3 Chlorpyrifos is not registered for pesticide use on rangelands and is extremely toxic to fish, birds, and other wildlife; therefore, it is not considered suitable for grasshopper control treatment. Carbofuran is of relatively high toxicity with a reported LD_{50} value of 8 mg/kg in comparison to rat oral LD_{50} values of carbaryl, acephate, and malathion ranging from 270 to 866 mg/kg. The reasons for eliminating

dimethoate from consideration are addressed in chapter 2 in the section entitled "Alternatives Eliminated from Detailed Study."

The IPM pilot project will continue to study various application rates, delivery methods, and treatment times to determine the most efficacious use of carbaryl, malathion, and acephate. In addition, other new methods are being tested (see chapter 2).

27-4 One of the aims of the IPM pilot project is to test each control method at its optimum treatment window.

27-5 As noted in the section on the IPM pilot project in chapter 2 of the final EIS, microencapsulated malathion will be tested on 40-acre blocks during the first year of the project. This acreage would be too small to conduct environmental monitoring. If microencapsulation is tested on larger acreages in the future, monitoring for nontarget effects would occur. Also, note that the operational procedures for bee protection in table 2-1 would apply to any methods that are incorporated into APHIS' cooperative control program.

27-6 See response 6-6. Possibilities for future research on prescribed burning and grazing management and tentative work plans for the IPM pilot project are described in chapter 2.

27-7 A reference has been added to the text. The stage for most effective transmission is third instar nymphs.

27-8 We agree. See response 4-5.

27-9 The concept of reduced longevity caused by higher incidences of parasites and predators when grasshopper densities are high has been incorporated into the section entitled "Biological Control Methods Alone" in chapter 2.

27-10 See response 5-6.

27-11 The costs shown in table 4-31 include material, support, and application costs for an entire control program. The private cooperator pays one-third to two-thirds of this cost. The value of the forage protected will vary on a case-by-case basis. Table 4-30 shows the amount of forage destroyed, in animal unit months, for each of the eight analysis regions. Again, the value of these forage amounts will vary based on regional range conditions and land uses.

27-12 See responses 19-2 and 19-3.

27-13 The species you have listed have been added to figure 3-7 in response to your comment.

27-14 Additional data to be collected at 60 IPM data-gathering sites include information on grasshopper species present at each site and their stage of development. See response 5-2. Appropriate field personnel for gathering these data will be hired under the IPM pilot project.

27-15 The IPM pilot project includes an evaluation component that will identify the current season and long-term control achieved on test sites. See response 5-12.

27-16 APHIS has determined through past experience that counting eggs is time-consuming, difficult in terms of egg pod location, and does not result in valuable information. During the routine nymphal survey, the surveyor makes an assessment of the role of egg hatching in influencing grasshopper populations. In addition, the IPM pilot project will include gathering data on egg production on 60 sites within and outside the demonstration area. These data will be used to further develop APHIS' phenology model, which will make counting eggs unnecessary for predicting outbreaks.

27-17 Sampling of water for residues after treatment will take place approximately 15 to 30 minutes after spraying. In 1987, APHIS' routine monitoring procedures will be expanded to include residue analysis on sediment. In addition, special environmental monitoring in sensitive areas and monitoring within the IPM demonstration area will include sampling effects in aquatic macroinvertebrates.

27-18 The text has been revised to indicate that these figures are based on pesticide manufacturers data submitted to EPA.

27-19 All workers will be required to comply with the operational procedures in APHIS' cooperative control programs. These procedures address your specific points.

27-20 See responses 6-13 and 20-16.

27-21 If uncontrolled infestations result in extreme losses of food and cover for wildlife, it is possible that individual animals could die. In response to your second point--because the amount of carbaryl bait required to be eaten in order to show toxic effects

is relatively low--it is possible for granivorous species feeding on the bait to be adversely affected.

Letter 28

Thank you for your comments.

Letter A

A-1 Your comments have been noted.

A-2 See response 5-11. A description of the research to be conducted on range management under the first year of the IPM pilot project has been incorporated into chapter 2 of the final EIS.

A-3 As described in response 5-2, APHIS is building a data base composed of many of these elements in order to improve its predictive modeling capabilities. Using these data, along with posttreatment environmental effects monitoring data, APHIS can improve its ability to select a management strategy that optimizes control while minimizing environmental disruption. Each of the "decision points" you have listed will be considered in preparing site-specific environmental assessments.

A-4 Each of these items is addressed in the responses to your specific comments.

A-5 Thank you for your comments.

A-6 In preparing the EIS, APHIS has reviewed the best available studies, including those recommended by the Fish and Wildlife Service (see comment letter B). The risk analysis in this EIS examined exposures and risk to individual birds and animals; and population effects were extrapolated based on the characteristics of broadscale APHIS operations. APHIS has concluded that there should be no significant threat to a given species throughout its overall range. Because less than 1 percent of the total western rangeland acreage is likely to be sprayed in any one season, only a fraction of the total range of most wildlife species would be affected.

The effects of the localized loss of prey base and changes in foraging behavior are addressed in chapter 4. APHIS has recently prepared guidance for field personnel preparing site-specific environmental assessments (EA's). This guidance requires that site-specific EA's consider impacts of alternative treatments on unstable or limited range populations.

A-7 APHIS has attempted to clarify how environmental documentation will be tiered to the programmatic EIS, who prepares site-specific EA's, and what must be considered in site-specific EA's in chapter 5 of the

final EIS. In addition, the recently prepared guidance for preparing site-specific EA's is available on request from APHIS.

A-8 The procedures for protecting endangered and threatened species have been clarified in table 2-1 of the final EIS and in chapter 5 in the section entitled "Endangered and Threatened Species and Critical Habitat Requirements." As explained in these sections, the Biological Assessment prepared by APHIS contains specific proposed protection measures for endangered and threatened species. These protection measures are subject to modification in the Biological Opinion, which will be prepared by the Fish and Wildlife Service. APHIS is committed to complying with all protection measures as they are developed and documented in consultation with the Fish and Wildlife Service.

The Biological Assessment analyzes the effects of the APHIS program insecticides on endangered and threatened species. The determination of whether a particular method is not acceptable on a given site because of potential adverse effects to endangered species will be made in site-specific field-level conferences with Fish and Wildlife Service personnel.

Also, see response 6-13 regarding consideration of Federal, candidate, and State-listed species in site-specific EA's.

A-9 The information on endangered species that will be on the product labels will assist APHIS in meeting its program requirements for identifying listed species that may be within proposed treatment areas. (Currently this information is compiled for the Biological Assessment.) When it is determined that these species are listed in a county containing a proposed treatment site, the Fish and Wildlife Service will assist APHIS with biological and distributional data. APHIS will comply with all label restrictions, including those designed to protect endangered and threatened species.

A-10 Current season mortality assessments are a part of all APHIS control programs. The evaluation program to determine long-term success in achieving control will be refined during the IPM pilot project so that it can be applied to standard APHIS programs.

A-11 With regard to retreatment, see response 1. APHIS has considered the cumulative impacts of pesticides used by APHIS in conjunction with those used by other agencies and groups. See the section entitled "Cumulative

Effects" in chapter 4. The APHIS guidance for preparing site-specific environmental assessments will require APHIS personnel to identify any other pesticide programs that may have occurred in the vicinity that season or in the previous season if reliable information is available. At that time, a decision will be made regarding the appropriateness of conducting a grasshopper control program in that area.

A-12 In response to your comment, the text in chapter 2 to which you refer has been revised. Please note that both short- and long-term efficacy would be considered in approving a method for field use.

A-13 The economic research component of the IPM pilot project will expand upon the quantitative long-term benefits of chemical and nonchemical methods. See the revised text in the section entitled "The IPM Pilot Project" in chapter 2.

A-14 The source for the information on Nosema in table 4-32 was the supplier. Although the supplier has not subsequently suggested revisions to that table in his comment letter, he has commented that, as demand for and production of Nosema increase, these costs will go down. See comment letter 13.

A-15 The text in the section entitled "Sociological Impacts on the General Public" has been revised in response to your comment. The effects on aesthetic resources have been addressed in the section entitled "Visual Resources" in chapter 4. Operational procedures require a 500-foot buffer zone for recreational facilities when using chemical sprays or baits. The water protection requirements and buffer zones should protect any sport fisheries. Finally, the wildlife impacts analysis does not indicate that big-game species would be affected by treatments. However, a reduction in prey bases for small game and game birds could cause localized reductions or displacement, thus affecting local hunting opportunities.

A-16 In response to your comment, APHIS has conducted additional analyses of routine exposures to mixer/loaders and pilots. See the revised human health section in chapter 4 and the exposure analysis in appendix B.

A-17 APHIS treats infestations only on request from landowners and land managers. Note that from 1972 to 1985, an average of only 11 percent of rangelands on which economically important populations occurred were actually treated. Thus, the majority of infestations run

their natural course. Nontreated areas will be monitored for rangeland recovery in the IPM pilot project.

Letter B

B-1 Thank you for your comments.

B-2 It is possible that the use of Sevin 4-Oil with diesel oil will reduce the survival of bird embryos and diminish the reproductive success of nesting birds in the treated area. The exposure calculations on oil contamination of eggs have been expanded in appendix B of the final EIS, and the wildlife risk analysis and multiple applications discussion reflect the findings. These effects should not affect species populations overall. If a site-specific assessment indicates that a limited range or unstable bird population may be adversely affected by Sevin 4-Oil, an alternative method would be selected.

B-3 Carbaryl baits are most effective if applied earlier in an infestation (see table 2-4). If a request is made to treat an outbreak that has already reached the later nymphal or adult stages, sprays would be needed. APHIS agrees that carbaryl bait would have environmental advantages over ULV sprays and would be the method of choice in certain situations. However, note that the risk analysis indicates higher risk to some small granivorous species that ingest bran bait than if the same species were exposed to spray.

B-4 Research will continue on Entomopox viruses and *E. grylli*. See the revised sections entitled "Potential Future Components of IPM" and the "IPM Pilot Project" in chapter 2.

B-5 The text in the final EIS has been clarified to refer to the 1987 Biological Assessment that has been prepared. That Biological Assessment has been submitted to the Fish and Wildlife Service.

B-6 Endangered and threatened species that are listed for a county in which a treatment is proposed will be addressed in the site-specific environmental assessment for that treatment, and protection measures developed in consultation with the Fish and Wildlife Service will be followed. APHIS will confer with the Fish and Wildlife Service at the field level to obtain biological and distributional data to assist in the EA process.

B-7 All of these points are objectives of the IPM pilot project. See the new section entitled the "IPM Pilot Project" in chapter 2 for details.

B-8 APHIS agrees that below certain levels, grasshoppers are important to a healthy range ecosystem; and that when relatively few grasshoppers are present, feeding is more selective. However, the damage described in the EIS to which you refer occurs when grasshoppers reach high densities. The section entitled "Need for Control Activities" in chapter 1 provides numerous references on the damage caused by grasshopper outbreaks.

B-9 The draft EIS uses a set of representative species typical of much of the rangeland in the West to analyze impacts on wildlife. It would not be practical to analyze the impacts on every species of wildlife on rangelands. The analysis in the final EIS serves as the background for the consideration of the actual species present on a treatment site in the site-specific analyses.

The risk analysis of chemical controls in chapter 4 of the final EIS discusses the possibility of direct and indirect impacts on wildlife species. Serious direct toxic effects to most wildlife species are not expected to occur. However, loss of insect food supplies, behavioral anomalies caused by cholinesterase depression, and some toxicity to birds' eggs are possible effects of control programs. Also, see response B-12 below.

B-10 The half-lives of each of these chemicals in plants are relatively short (1 to 2 weeks); thus, firefighters are not likely to be exposed to significant amounts of their combustion products. In addition, local police and fire officials will be notified of pesticide storage and treatment areas so that they can take the necessary precautions (see table 2-1).

B-11 While you are technically correct, APHIS has not underlined Nosema throughout the text for ease of reading and for production purposes.

B-12 APHIS has reviewed each of the studies cited by the commenter. They have not caused APHIS to change the conclusions in the wildlife analysis.

B-13 The text has been revised in response to your comment. The multiple resource values of the rangeland are noted in the paragraph preceding the one you have cited.

B-14 The sentence has been modified in response to your suggestion.

B-15 The findings of Dyer and Bokhari (1976) are described in chapter 1 in the section entitled "Life History and Ecology of Grasshoppers and Mormon Crickets." Again, these benefits are negated when grasshopper populations reach critically high densities. See response B-8.

B-16 These effects are discussed in chapter 4 in the wildlife impacts analysis.

B-17 It is possible that eggs may receive contaminants from incubating birds. Conversely, it is also possible for contaminants to be removed from eggs and deposited on incubating birds' feathers or on the surrounding nest material. The assumption that one-half of the surface area of the egg is exposed to direct surface deposition is considered reasonable to account for the dose to an egg from all sources.

B-18 The effects of the three chemicals on aquatic organisms are thoroughly analyzed in chapter 4 of the EIS. APHIS program records indicate that treatments in the same area generally do not recur within 7 years. Field personnel conducting site-specific analyses will be required to determine whether other spray projects have occurred in the previous season if reliable information is available. The effects of multiple grasshopper control applications within the same year are analyzed in the EIS in the event that they are necessary.

In response to your comment, APHIS has expanded its analysis on methamidophos toxicity for humans, wildlife, and aquatic species. Because aquatic toxicity values already account for the degradation products of acephate in water, effects of methamidophos on aquatic species were assumed to be the same as or part of those described for acephate. Refer to the aquatics risk analysis on acephate for further discussion.

B-19 APHIS will comply with all measures reached and documented in consultation with the Fish and Wildlife Service.

B-20 While it is true that there would be residual neurotoxic effects from accidental exposures, the additional exposures from subsequent routine activities would not produce "even more severe effects."

B-21 As evidenced in table 3-1 of the EIS, grasshopper infestations go beyond affecting individual ranchers. Widespread areas of infestation can affect entire ranching communities.

B-22 A complete discussion of other environmental effects including those from multiple applications may be found in chapter 4.

B-23 The text has been revised to include the findings of the National Park Service.

B-24 The source article for this information is Hewitt and Onsager (1983). Please refer to it for the assumptions used.

B-25 By "typical," APHIS is referring to the acreage treated in cooperative programs that year. While APHIS agrees that regional drought conditions affect local forage values and grasshopper population levels, the 1977 figure is an overall average for the western rangelands.

B-26 Maps of treatment areas are attached to individual work plans for each treatment. They are not compiled into one large map comparable to the national outlook map.

B-27 The text in chapter 1 has been revised to indicate that any moribund wildlife found during monitoring will be collected.

B-28 As stated in the section to which you refer, it is not practical to rely on these natural controls at outbreak levels; additional biological controls or chemical controls are needed.

B-29 As stated later in the section to which you refer, the buffer zones are designed to protect water bodies and sensitive areas from drift.

B-30 See response 1. The text to which you refer has been revised.

B-31 The required prespray reconnaissance flight will allow treatment personnel to identify these sensitive areas. In addition, detailed surface area maps or aerial photographs are reviewed prior to spraying. Flagging personnel or markers are used to guide the pilot; and spray planes are equipped whenever possible with electronic guidance equipment to facilitate accurate deposition over the target area.

B-32 See response B-2.

B-33 Lower application rates of carbaryl bait have not been adequately tested for large-scale applications such as those conducted by APHIS. (ARS research to date has been on much smaller acreages.) It should be noted

that pesticides may be applied at lower than labeled rates without a label change.

B-34 The text in chapter 2 and in table 2-6 has been changed to better reflect the difference in toxicity between malathion and carbaryl.

B-35 The correct amount is 5 microliters of No. 2 fuel oil. See the revised text in appendix A.

B-36 A polyacrylamide-acrylic acid polymer, such as Orthotrol or Nalcotrol, is used to minimize drift. See the revised text in chapter 2.

B-37 Refer to the environmental fate discussion of acephate in appendix B. A discussion on expected field degradation rates of acephate in the West has been included.

B-38 The toxicity of methamidophos and its environmental fate are included in appendixes A and B. An analysis of the risks associated with methamidophos has been incorporated into the risk analysis for humans and wildlife in chapter 4. Effects of acephate on pregnant or nursing animals are noted in the wildlife hazard analysis in appendix A. Also, note that the IPM pilot project will include a study on the acute oral toxicity of acephate and methamidophos to kestrels.

B-39 Migratory birds are common throughout the rangeland, and there could be no areas delineated where they are not present. The risk analysis has represented effects on migratory birds by examining impacts on the American kestrel and the lark bunting. The analysis shows that there should be no significant overall population effects. If a site-specific analysis indicates that a limited range or unstable population is at risk from oil or ULV sprays, carbaryl bait or Nosema may be the method of choice.

The IPM pilot project will include further research on the effect of oil and ULV formulations to migratory birds in grasshopper control. This research has been developed in cooperation with the Fish and Wildlife Service. (See chapter 2.)

B-40 At certain levels of infection, the Nosema-treated individuals die. There is no question that no foraging by grasshoppers (that is, lower survival rates) is a better form of control than reduced foraging at high outbreak levels.

B-41 The tentative work plans for research on E. grylli and entomopox viruses for the first year of the IPM pilot project have been incorporated into chapter 2 of the final EIS.

B-42 The monitoring programs and research on migratory birds that have been further developed in cooperation with the Fish and Wildlife Service since the publication of the draft EIS are now described in more detail in chapter 1 of the final EIS in the section entitled "Monitoring" and in chapter 2 in the section entitled "The IPM Pilot Project." The monitoring plans for standard programs, sensitive areas, and the IPM demonstration sites are presented in appendix C.

B-43 The cyclical nature of grasshoppers is discussed in chapter 1 in the section "Target Organisms."

B-44 See the revised text in the table.

B-45 See the revised text in the table.

B-46 APHIS is aware of these additional buffer zones proposed in the past and is awaiting their finalization in the 1987 consultation process. As stated in table 2-1 and chapters 4 and 5, APHIS will follow all protection measures developed and documented in the consultation process and in the Biological Assessment and Biological Opinion. With regard to the monitoring program, see response B-42.

B-47 An analysis of formaldehyde has been added to chapter 4 and appendixes A and B.

B-48 A general description of regional rangeland conditions is given in the "Land Uses" section of the overview in chapter 3. The regional forage production and stocking levels, which generally reflect rangeland condition, are given in table 3-2.

B-49 In response to your comments, the 1987 Biological Assessment has been referenced in the wildlife section in the overview of chapter 3. In addition, endangered and threatened species have been listed in the overview and in sections on specific analysis regions in response to other comments you have provided. State-listed species will be identified and addressed in site-specific environmental assessments.

B-50 See response 20-24.

B-51 The text has been revised in response to your comment.

B-52 The text has been revised in response to your comments.

B-53 The sentence to which you referred is misleading and has been deleted. The importance of water resources to wildlife in the prairie regions has been noted in the text.

B-54 These species have been added to chapter 3 in response to your comments. Also, see response B-9.

B-55 See response B-39.

B-56 Maps of areas sprayed accompany each specific work plan--they are not compiled into large area maps. APHIS program records indicate that from 1970 to 1979, an average of 1.7 million acres were sprayed annually. This constitutes less than .03 percent of the total rangeland acreage. Thus, it is highly unlikely that the declining bird populations you have described can be attributed to APHIS grasshopper programs. Note that a 5-year research project that will study the effects of broad-scale grasshopper programs on bird populations is planned. (See the discussion of the IPM pilot project in chapter 2.)

B-57 In response to your comments, wilderness areas have been identified in chapter 3 under the section entitled "Cultural and Visual Resources." The procedure by which treatments are authorized and impacts from grasshopper control activities to wilderness areas are evaluated has been added to chapter 5 under "Recreation Resources Requirements."

B-58 In response to your comment, the federally threatened and endangered species have been added to the text. Proposed species will be addressed in accordance with the Endangered Species Act.

B-59 See response B-58.

B-60 The text has been revised in response to your comment.

B-61 See response B-58.

B-62 The text has been revised in response to your comment.

B-63 The text has been revised to list the sage grouse. Candidate species will be addressed in the site-specific environmental assessments.

B-64 The text has been revised in response to your comment.

B-65 The text has been revised in response to your comment.

B-66 The text has been revised in response to your comment.

B-67 The text has been revised in response to your comment.

B-68 The erosion impacts caused by cattle grazing are beyond the scope of the EIS. According to Hewitt and Onsager (1983), overgrazing by grasshoppers is at least as detrimental as overgrazing by cattle.

B-69 The 1987 Biological Assessment includes proposed protective measures for endangered and threatened plants in the event that it is determined that program impacts on wild pollinators could affect the reproductive success of those plants. These measures will be reviewed for approval by the Fish and Wildlife Service, and any modifications will be presented in the Biological Opinion. The text has been revised to clarify this point.

B-70 The pronghorn was mistakenly omitted from the original list of representative mammals in the draft EIS. However, both the pronghorn and beef cow were included in the wildlife risk analysis.

B-71 With respect to the question of whether the risk analysis was conservative, as discussed in the wildlife impacts section of chapter 4, each representative species was assumed to receive a dermal dose based on insecticide deposited on its entire body surface and an additional dose from contacting vegetation with insecticide residues. It was assumed to consume nothing but contaminated food items that had also received residues of insecticide over their entire surface, to inhale insecticide, and to drink water with insecticide residues. This multiplicity of exposures, with no degradation or other loss of insecticide considered, was believed to be a reasonably conservative methodology for estimating possible doses.

B-72 With regard to your point about effects other than direct massive mortalities, behavioral effects, including effects on food gathering and reproduction, are considered throughout the wildlife impacts section of chapter 4.

B-73 Concerning the consideration of other environmental stresses, a risk assessment model that included environmental stresses (weather, predation, parasites, diseases, competition) would be far too complex and unwieldy to use at the programmatic level. Implicit in

the analysis of insecticide effects is the assumption of "all other things being constant." The discussion of risk does, however, acknowledge the effects of other environmental stresses.

B-74 Concerning the comment that the EIS assumes that dosages are known, the analysis attempts to make a reasonably conservative estimate of doses because dosages are not known. The environmental monitoring component of the IPM pilot project should yield data on dosages under field conditions.

B-75 With respect to the consideration of contamination of eggs by incubating parents, see response B-17. Apart from this particular possibility, the analysis does consider all other routes of exposure to wildlife.

B-76 With regard to risk to incubating bird clutches in cold, wet weather, APHIS operational procedures prohibit insecticide application in cold, wet weather.

B-77 With regard to food requirements for growing birds, see response B-72.

B-78 Concerning the suggestion of using no-observed-effect levels (NOEL's) in assessing wildlife risk, NOEL's are generally available only for a very few laboratory test species (usually rats or mice) in long-term testing. Testing on wildlife species is generally limited to acute toxicity. In addition NOEL's would not be appropriate levels for comparison because insecticide spraying for grasshopper control would constitute a single short-term exposure and a NOEL is a long-term toxicity reference level.

EPA identifies doses that equal or exceed one-fifth of the LD_{50} as constituting risk that may be mitigated by restricted use (see table 4-2). EPA also states on page 5 of its Ecological Risk Assessment document (U.S. EPA, 1986a) that 1 in 1,000 of the typical population exposed to pesticides is likely to die when the safety factor of 5 is used. Thus, the additive risk of direct toxicity in conjunction with other environmental stresses is not a significant issue with doses below one-fifth of the LD_{50}, although cholinesterase depression causing behavioral anomalies may cause adverse effects.

B-79 With regard to the complexity of the model and its referencing in chapter 4, it should be noted that chapter 4 contains a summary of the model. It is

discussed in detail in appendix B, which contains a separate references section.

B-80 Concerning the American kestrel's dose, APHIS has recomputed the dose so that it receives exposure from inhalation and dermal routes and feeds exclusively on contaminated grasshoppers. The increased doses do not lead to a change in the conclusions about effects on the kestrel.

B-81 Concerning the surface area for deposition on birds, the surface area formula applies to the area of skin surface that has been shown to be a function of the body weight to the 2/3 power in terrestrial vertebrates. Feather surface area is not considered per se; however, it is assumed that pesticide does reach the bird's skin and a portion of that penetrates to become a direct dermal dose. In fact, as discussed in appendix B of the EIS, feathers would be likely to limit any deposition at all on the skin surface so that the only dose would come from preening. Thus the error in estimation of the preening dose is offset by overestimating the dose through the skin.

B-82 With respect to the variables VCP and PBG, as explained in appendix B, these variables were used in the model to simplify the analysis. No better estimates of these amounts were suggested during the review process for this EIS, in which the commenter was involved.

B-83 The U.S. Department of the Interior (1963a) reference has been added to the references section; the other references are already included in the references section.

B-84 Operational procedures prohibit spraying at extremely high temperatures. Grasshoppers are inactive during low temperatures, thus treatments would not be necessary or efficacious.

B-85 The statement to which you refer indicates that carbaryl did not show significant direct toxic effects to nontarget mammals in the field. The findings of declining grasshopper mouse populations have been added as an indirect effect of any control alternative, rather than as a specific effect of using carbaryl.

B-86 APHIS agrees that opportunistic feeding outside the spray area would probably not be a viable option for all of the birds in a sprayed area, although birds on the periphery would not be affected to the degree that those in the interior are. To some extent, this effect

should be mitigated by the fact that the control methods are not 100 percent effective against grasshoppers, so that some grasshoppers and other unaffected insects should remain alive as a bird prey base. These effects have been studied by the University of Wyoming (currently unpublished), are being studied by New Mexico State and South Dakota State universities, and will be further studied under the IPM pilot project.

B-87 See response B-72.

B-88 A cumulative analysis of insecticide dosing was not done because the doses on the first day were considered to far exceed any subsequent exposures and only acute toxic effects were of concern. The impacts of multiple chemical applications within a season are addressed in chapter 4.

B-89 The information you have provided on the Snake River has been included; however, specific locations of previous control treatments are not identified in this programmatic EIS.

B-90 As shown in table 1-1, the total acreage treated in 1985 is more than twice the amount treated in the next highest year and is therefore not representative of the average acres treated annually. Based on the average acreage treated from 1972 to 1986, the area treated in a given year would not exceed 1 percent of each rangeland region.

B-91 In response to your comment, consideration of synergistic and additive effects of carbaryl and diesel and petroleum oils has been included in the human health risk analysis in chapter 4.

B-92 The 1-mile no-treatment zone is consistent with the U.S. Fish and Wildlife Service peregrine falcon recovery plan to prevent human disturbance. Other measures will be taken to protect the hunting radius as developed in consultation with the Fish and Wildlife Service and presented in the Biological Assessment/Biological Opinion.

B-93 In response to your comment, the text has been revised to indicate that no significant direct toxic effects to wildlife have been indicated in field studies.

B-94 See response B-46.

B-95 The restrictions on dairy cattle are to limit possible contamination of milk for human consumption.

An analysis of wild herbivore milk contamination was not considered necessary.

B-96 See response B-72.

B-97 See response B-46.

B-98 As stated in the revised text in chapter 2 of the final EIS, the environmental evaluation component of the IPM pilot project will include a determination of the incidence of lordosis in larval and juvenile roundtail chub in the Green and Yampa Rivers before and after spraying for Mormon cricket control near the Dinosaur National Monument.

B-99 The text and table to which you refer have been revised in response to your comment.

B-100 The information on the volume of the plane load and the reservoir is in the section entitled "Exposure Analysis" in chapter 4. The concentrations of malathion, carbaryl, and acephate are approximately 91 to 95 percent, 35 percent, and 4.5 percent by weight, respectively.

B-101 The 500-foot buffer zone applies to wetlands. See revised table 2-1.

B-102 Analyses of concentrations of wildlife in critical areas are more appropriately addressed at the site-specific level.

B-103 See response B-57.

B-104 The text has been revised in response to your comment.

B-105 See response B-4.

B-106 Training of field personnel is an ongoing activity as new methods become operational. The APHIS Program Manual is also updated to reflect operational requirements as they are incorporated into the program. As more is learned regarding the optimum use of Nosema in the IPM pilot project, the results will be supplied to all field personnel and land owners/managers.

B-107 See responses 5-2 and 5-6. APHIS has no plans to study economic thresholds for Mormon crickets in the first year of the IPM pilot project. The status of research on Mormon crickets conducted by Coloràdo State University under contract with the National Park Service has not been published and made available to APHIS.

B-108 Any of the approaches being field-tested in the IPM pilot project or in APHIS' methods development activities and that are adopted for use in cooperative programs will be available for treating incipient infestations.

B-109 APHIS will conduct field testing of any method that shows promise in research. APHIS will follow the work to which you have referred.

B-110 See response 5-24.

B-111 It is impossible to conduct nymphal surveys at the level of intensity suggested by the commenter throughout the rangeland areas of the 17 western States and Alaska. See response 5-2 with regard to efforts to improve predictive modeling capabilities through increased data gathering under the IPM pilot project.

B-112 The monitoring plan for standard programs, sensitive areas, and the IPM demonstration site is designed as a holistic approach (see appendix C). Environmental effects monitoring that cannot be accomplished on the IPM demonstration site may take place elsewhere. For example, the lordosis studies will take place near Dinosaur National Monument.

B-113 The description of the special monitoring program in chapter 1 has been revised, and it is pointed out that the proposed criteria for determination of sensitive areas and the monitoring design presented in appendix C and the Biological Assessment are subject to change as a result of the Biological Opinion.

B-114 See response B-42.

B-115 See response B-3.

Appendix E
Glossary

Acetylcholine--A chemical involved in transmission (carrying) of nerve impulses across junctions in the nervous system.

Acetylcholinesterase (AChE)--An enzyme produced at junctions in the nervous system that inactivates acetylcholine, thereby ending transmission of a nerve impulse once it has passed the junction.

Active ingredient (a.i.)--The effective part of a pesticide formulation or the actual amount of the technical material present in the formulation.

Acute toxicity--The potential of a substance to cause injury or illness when given in a single dose or in multiple doses over a period of 24 hours or less; in aquatic studies, exposure to a given concentration for 96 hours or less.

Absorption--The taking up of liquids by solids or the passage of a substance into the tissues of an organism as the result of several processes; that is, diffusion, filtration, or osmosis.

Adsorption--Adhesion of substances to the surfaces of solids or liquids. Technically, the attraction of ions of compounds to the surfaces of solids or liquids.

Alveolar--Pertaining to an air cell or air space in the lungs where gas exchange between the lung and capillary membranes occurs.

Amphipod--Any of a large group of small crustaceans with laterally compressed bodies commonly called scuds.

Animal unit--Considered to be one mature cow (1,000 pounds) or the equivalent based on average daily forage consumption of 26 pounds dry matter per day.

Animal-unit month (AUM)--The amount of feed or forage required by an animal unit for 1 month.

Arthropod--Members of the phylum Arthropoda include the insects, the crustacea (crabs, lobsters, and shrimp), the arachnids (spiders, ticks, and scorpions), the millipedes, and centipedes. The arthropod is characterized by a rigid external body covering called a cuticle or exoskeleton, a segmented body, and paired, jointed appendages with at least one pair of functional jaws.

Assay--A test or measurement used to evaluate a characteristic of a chemical. See bioassay.

Ataxia--Muscular incoordination; an inability to coordinate voluntary muscular movements.

Bioaccumulation--The process of a plant or animal selectively taking in or storing a persistent substance. Over a period of time, a higher concentration of the substance is found in the organism than in the organism's environment.

Bioassay--A method for quantitatively determining the concentration of a substance by its effect on the growth of a suitable animal, plant, or microorganism under controlled conditions.

Boom (insectide spray)--A tubular metal device that conducts a herbicide mixture from a tank to a series of spray nozzles. It may be mounted beneath a helicopter or a fixed-wing aircraft or behind a tractor.

Carcinogen--A substance that causes cancer.

Carrying capacity--The maximum stocking rate possible on a given amount of land without causing damage to vegetation or related resources. It may vary from year to year on the same area because of fluctuating forage production. Also called grazing capacity.

Cation--A positively charged ion; the ion in an electrolyzed solution that migrates to the cathode.

Chemical degradation--The breakdown of a chemical substance into simpler components through chemical reactions.

Cholinesterase (ChE)--Any enzyme that catalyzes the hydrolysis of choline esters; for example, acetylcholinesterase catalyzes the breakdown of acetylcholine to acetic acid and choline.

Chromatid exchange assay--Mutation assay designed to evaluate an alteration in the normal exchange of genetic material.

Chronic toxicity--Harmful effects of a chemical from prolonged exposure or repeated administration.

Class I Area--Areas of the United States (primarily national parks and wilderness areas) where ambient air concentrations of sulfur dioxide and particulate matter are allowed to be increased only minimally. Strict visibility standards are also effective around most class I areas.

Climax--The highest ecological development of a plant community capable of perpetuation under the prevailing climatic and edaphic conditions.

Conjunctivitis--Inflammation of the mucous membrane that lines the inner surface of the eyelids.

Cooperator--A State, Federal, or private individual, agency, or group that is involved in a grasshopper or Mormon cricket control program as a codecisionmaker or financially through an established cost-sharing formula.

Critical habitat--The specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the Endangered Species Act, on which are found those physical or biological features that are essential to the conservation of the species and that may require special management considerations or protection. Also included are specific areas outside the geographical area that is occupied by the species at the time it is listed that the Secretary determines are essential for the conservation of the species.

Cropland--Any area planted with the intent to harvest. Crops planted and then grazed because of drought or insufficient growth will be considered cropland. Fallow land also will be considered cropland.

Demyelination/Demyelinization--The destruction or removal of the myelin sheath of nerve tissue. The myelin sheath is composed of layers of myelin, a lipid material that provides electrical insulation and protection for the neuron.

DNA--Deoxyribonucleic acid. The nucleic acid containing the sugar deoxyribose, which is the molecular basis of heredity in many organisms.

Degradation--See chemical degradation and microbial degradation.

Dermal exposure--The portion of a toxic substance that an organism receives as a result of the substance coming into contact with the organism's body surface.

Dermatitis--Inflammation of the skin.

Desorption--The removal of ions or compounds attached to the surfaces of particles of soil or organic matter.

Diptera--Flies, mosquitoes, midges, and the like, that constitute a group of insects characterized by having only one pair of functional wings; a second nonfunctional pair is reduced to small knobbed structures called halteres.

Drift--That portion of a sprayed chemical that moves off a target site because of wind.

Dry weight--See oven-dry weight.

Dyspnea--Labored or difficult breathing, sometimes accompanied by pain. Normal when due to vigorous work or athletic activity.

EC_{50}--Median effective concentration. The concentration (ppm or ppb) of the toxicant in the environment (usually water) that produces a designated effect (usually immobilization) on 50 percent of the test organisms exposed. This is used primarily for microorganisms for which it is difficult or impossible to determine if individual organisms are alive or dead.

Edaphic--Of or pertaining to the soil.

Edema--An excessive accumulation of fluid in the cells, tissue spaces, or body cavities resulting from a disturbance in the fluid exchange mechanism. Also known as dropsy.

Endangered species--Any species of animal or plant that is in danger of extinction throughout all or a significant portion of its range.

Environmental analysis--Procedure defined by the National Environmental Policy Act of 1969 whereby the environmental impacts of a planned action (in this case grasshopper control programs) are objectively reviewed.

Esterase--Generic term for an enzyme that catalyzes the hydrolysis of esters.

Estimated environmental concentration--Estimated amount of insecticide residue that will be in the environment and available to the organism.

Exposure analysis--The estimation of the amount of chemicals that organisms receive during application of pesticides.

Forage--All browse and nonwoody plants available to livestock or wildlife for grazing or harvesting for feed.

Forage production--The weight of forage that is produced within a designated period of time on a given area. The weight may be expressed as either green, air-dry, or oven-dry. The term may also be modified as to time of production such as annual, current year's, or seasonal forage production.

Formulation--The form in which a pesticide is packaged or prepared for use. A chemical mixture that includes a certain percentage of active ingredient (technical chemical) with an inert carrier.

Fresh weight--The weight of plant materials at the time of harvest. Also called green weight.

Gavage--Feeding by way of a tube inserted into the stomach.

Granivorous--Feeding on grains and seeds.

Half-life--The time required for a substance (such as an insecticide) in or introduced into a living or nonliving system to be reduced to half of its original amount whether by excretion, metabolic decomposition, or other natural process.

Hazard analysis--The determination of whether a particular chemical is or is not causally linked to particular harmful effects.

Herbivore--An animal that feeds exclusively on plants.

Histology--Study of the microscopic structure of tissue.

Horizons (soil)--A layer of soil, approximately parallel to the soil surface, with distinct characteristics produced by soil-forming processes.

Hydrolysis--Decomposition or alteration of a chemical substance by water.

Hymenoptera--A large order of insects comprised of the ants, bees, sawflies, and wasps. The typical adult has four membranous wings and chewing type mouthparts.

Integrated Pest Management (IPM)--The selection, integration, and implementation of pest control tactics in a systems approach on the basis of anticipated economic, ecological, and sociological consequences.

Indicator species--Species that indicate the presence of certain environmental conditions, seral stages, or previous treatment. Also, one or more plant species selected to indicate a certain level of grazing use.

Insectivorous--Insect-eating; in common usage, includes animals that eat insects and sometimes other selected invertebrates.

Instar--The term for an insect before each of the moults (shedding of its skin) it must go through in order to increase in size. Upon hatching from its egg, the insect is in instar I and is so called until it moults, when it begins instar II, and so forth.

Intraperitoneal--Related to a structure or process occurring within the peritoneum, a membranous lining of the body cavity.

Isopod--Any of a large order (Isopoda) of small crustaceans with the body composed of seven free thoracic sections, each bearing a pair of similar legs. Commonly called sowbugs.

LC_{50}--Median lethal concentration. A lethal concentration rate at which 50 percent of the test animals will be killed. It is usually used in testing fish or other aquatic animals.

LD_{50}--Median lethal dose. The dosage of toxicant, expressed in milligrams of toxicant per kilogram of body weight (mg/kg), required to kill 50 percent of the animals in a test population when administered orally.

Leach--Usually refers to the movement of chemicals through soil by water; may also refer to the movement of herbicides out of leaves, stems, or roots into the air or soil.

Lepidoptera--A large order of insects, including the butterflies and moths, characterized by four scale-covered wings and coiled, sucking mouthparts.

LOAEL--Lowest dose level at which toxic effects are observed.

Lordosis--Abnormal forward curvature of the spine.

Metabolite--A product of the chemical changes in living cells that provides energy and assimilates new material.

mg/kg--Milligrams per kilogram. Used to designate the amount of toxicant required per kilogram of body weight of test organisms to produce a designated effect; usually the amount necessary to kill 50 percent of the test animals. 1 mg/kg = 1 ppm. 1 mg = 0.000035 ounce. 1 kg = 2.2 pounds.

mg/kg/day--Milligrams per kilogram of body weight per day.

Microbial degradation--The breakdown of a chemical substance into simpler components by bacteria.

Microcrustacean--Very small crustaceans, frequently abundant in fresh water. Size range is roughly 0.2 to 40 mm.

Microgram--One-millionth of a gram. Abbreviated as ug.

Micron--A unit of length equal to one-millionth (10^{-6}) of a meter.

Microsporidian--A class of protozoan parasites of arthropods and fishes.

Mutagen--A substance that tends to increase the frequency or extent of genetic mutations (changes in hereditary material).

NOEL--The no-observed-effect level. In a series of dose levels tested, it is the highest level at which no effect is observed; that is, safe in the species tested.

Necrosis--Death of a cell or group of cells as a result of injury, disease, or other pathologic state.

Neuropathy--Any disease affecting neurons, the fundamental functional unit of nervous tissues.

ODT--Only dose tested.

Omnivorous--Eating both animal and vegetable substances.

Oncogenic--Capable of producing or inducing tumors, either benign (noncancerous) or malignant (cancerous), in animals.

Oven-dry weight--The weight of a substance after it has been dried in an oven at 105 °C to equilibrium.

Parenteral--Introduced into the body by means other than the digestive tract.

Percolation--The flow of a liquid through a porous substance.

Pesticide--Any substance or mixture of substances used in controlling insects, rodents, fungi, weeds, or other forms of plant or animal life that are considered to be pests.

Phenology--The study of the relationship between climatic conditions and periodic biological phenomena (such as grasshopper outbreaks). Phenology models rely on this relationship, based on weather and biological data collected in the past, to predict recurrence of such phenomena.

Photochemically reactive--A property of substances or particles whose structures may be changed when solar energy is absorbed.

Photodecomposition--The breakdown of a substance, especially a chemical compound, into simpler components by the action of radiant energy.

Phytotoxic--Poisonous or harmful to plants.

Piscivorous--Habitually feeding on fish.

Plecoptera--Stoneflies. Group of insects, the nymphs of which are aquatic and mostly phytophagous.

Ppb (parts per billion)--The number of parts of a substance per billion parts of a given material. 1 ppb = 1 ug/liter (water or air).

Ppm (parts per million)--A unit for measuring the concentration of a substance (such as a pesticide) in a carrier medium (such as food or water). For example, where the concentration is 1 ppm, the weight of the substance is 1 millionth the weight of the carrier medium; thus, 1 ppm is equal to 1 millionth of substance per kilogram of food or organism body weight, and it is equal to 1 milligram of substance per liter of water.

Prescribed burning--The use of fire as a management tool under specified conditions for burning a predetermined area.

Primary production--The conversion of solar energy to chemical energy through the process of photosynthesis. It is represented by the total quantity of organic material produced within a given period by vegetation.

Protozoan--Members of the phylum Protozoa include the Mastigophora, opalinatea, sarcodinea, ciliophora, sporozoa, and cnidospora. They are single-celled or acellular organisms. They lack tissues and organs. Functionally differentiated parts of the protozoan are the organelles. A period of encystment is commonly a part of the life cycle. With the exception of cysts, all protozoans are confined to moist places.

Ptosis--Dropping or drooping of an organ or part, as the upper eyelid from paralysis or the visceral organs from weakness of the abdominal muscles.

Pulmonary--Concerning or involving the lungs.

Rangeland--Any area on which the vegetation consists of native or introduced grasses, legumes, grasslike plants, forbs, or shrubs, and that is developed for range (grazing) use. Also counted as rangeland are native pastures or meadows that are occasionally cut or mechanically harvested and are grazed by livestock.

Residue level--Amount of pesticide that may remain on a crop after harvesting.

Respirable particle--Particle of a size small enough to reach the lungs when inhaled.

Riparian area--Land areas that are directly influenced by water. They usually have visible vegetative or physical characteristics reflecting this water influence. Stream sides, lake borders, or marshes are typical riparian areas.

Riparian habitat--Those terrestrial areas where the vegetation complex and microclimatic conditions are products of the combined presence and influence of perennial or intermittent water, associated high water tables, and soils that exhibit some wetness characteristics. Includes riparian zones plus one-half the transition zone (or ecotone) between riparian zones and upland habitat.

Runoff--That part of precipitation, as well as any other flow contributions, that appears in surface streams, either perennially or intermittently.

Safety factor--A factor conventionally used to extrapolate human tolerances for chemical agents from no-observed-effect levels in animal test data.

Subchronic--The effects observed from doses that are of intermediate duration, usually 3 months or less.

Surfactant--A material that improves the emulsifying, dispersing, spreading, wetting, or other surface-modifying properties of liquids.

Suspended sediment--Sediment suspended in a fluid by the upward components of turbulent currents or by colloidal suspension.

Systemic toxicity--Effects produced as a result of the distribution of a poison or foreign substance from the point of exposure to a distant site within the body.

Tachinidae--Family of flies, the larvae of which are parasitic.

Tenesmus--Spasmodic contraction of anal or vesical sphincter with pain and persistent desire to empty the bowel or bladder with involuntary ineffectual straining efforts.

Teratogen--A substance tending to cause developmental malformations in unborn human or animal offspring. Teratogenicity is the capacity of a substance to cause anatomical, physiological, or behavioral defects in animals exposed during embryonic development.

Tetany--A nervous affliction characterized by intermittent tonic spasms, which are usually paroxysmal and involve the extremities; most frequent in the young and frequently associated with pregnancy or lactation.

Threatened species--Those plant or animal species identified by the Secretary of the Interior as threatened, in accordance with the Endangered Species Act of 1973, and likely to become an endangered species throughout all or a significant portion of their range within the foreseeable future.

Threshold limit value (TLV)--The concentration of an airborne constituent to which workers may be exposed repeatedly, day by day, without adverse effect.

Tolerance level--Legal enforcement levels that are set by EPA well below levels that might cause harm to humans or the environment.

Toxicity--A characteristic of a substance that makes it poisonous.

Translocation--The transfer of substances from one location to another in the plant body.

Turbidity--Quality of not having translucent appearance of liquid due to growth of microorganisms. Having flaky or granular particles suspended in a clear liquid, giving it a cloudy appearance.

Understory--Plants growing beneath the canopy of other plants. Usually refers to grasses, forbs, and low shrubs under a tree or brush canopy.

Volatility--The tendency of a substance to evaporate at normal temperatures and pressures.

Wetland or wetland habitat--Permanently wet or intermittently flooded areas where the water table (fresh, saline, or brackish) is at, near, or above the soil surface for extended intervals; where hydric wet soil conditions are normally exhibited, and where depths generally do not exceed 2 meters. Vegetation generally comprises emergent water-loving forms (hydrophytes) that require at least a periodically saturated soil condition for growth and reproduction. In certain instances, vegetation may be completely lacking.